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ENGINEERING:

An Illustrated Weekly Journal.

EDITED BY WILLIAM H. MAW AND B. ALFRED RAWORTH.

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And Auxiliary Machinery as supplied to the Admiralty. 2179

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See Illustrated Advertisement
Page 18, June 13.

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See page 17, July 4. 7363

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7182
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Specification and Workmanship equal to Main Line Locomotives.
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See page 15, July 4. 7454

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WORKS: SALFORD, MANCHESTER. 7186

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6820
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See Advertisement page 101.

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CARDIFF WAREHOUSE—132, BUTE ST.
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See Advertisement page 20. 7308

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Metallic Hose-Covering
to protect & strengthen tubing for all pressures and purposes. As supplied for H.M. Govt.—AERATORS LTD., Edmonton, London, N. 18.

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See Illus. Advt. last week, page 15. 7046

Patent
See's Hydro-Pneumatic **Ash Ejector.**
Great saving of labour. No noise. No dust. No dirt. Ashes discharged 20ft. clear of vessel.—Apply, F. J. TREWENT & PROCTOR, LTD., Naval Architects and Surveyors, 43, Billiter Bldgs., Billiter St., London, E.C. Od 4536

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NORMAND'S Patent Water-tube Boilers, Coal or Oil Heating. Diesel Oil Engines.

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See Advertisement page 37, July 4. 8468

Matthew Paul & Co., Ltd.
Dumbarton. 7060
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See Full Page Advt., page 83, June 27.

Taylor & Challen
Presses.
3103
TAYLOR & CHALLEN, LD., Engineers, BIRMINGHAM
See Full Page Advertisement, June 27.

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THE
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(Proprietors, Peter Hooker, Ltd.),
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Driving Pulleys of Aluminium
See Pulleys Leaflet
by
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Steam Hammers,
Power Hammers,
Drop Stamps,
Band Saws.
QUICK DELIVERY. LARGE STOCK. 7286

The Manchester Steam Users' ASSOCIATION.

For the prevention of Steam Boiler Explosions and for the Attainment of Economy in the Application of Steam. 9, MOUNT STREET, MANCHESTER.

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Founded 1854 by SIR WILLIAM FAIRBAIRN.

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University of Liverpool,

SESSION 1918-19.

FACULTY OF ENGINEERING.

Dean—Associate Professor J. WENYSS ANDERSON, M.Eng., M.Inst.C.E.

Prospectuses and full particulars of the following may be obtained on application to the REGISTRAR:

Engineering, Electrical Engineering, Civil Engineering, Naval Architecture, Marine Engineering, Engineering Design and Drawing, and Refrigeration, Mathematics, Physics, Chemistry. S 593

Pursuant to an Order of the

Chancery Division of the High Court of Justice, made in the Matter of the Estate of HENRI DESPAIGNE deceased and in an action BRUN *versus* DESPAIGNE, 1919 D. 468, the creditors of Henri Despaigne, late of 36, Holland Park, in the County of London, but formerly of 15, Dartmouth Street, Westminster, in the County of London, Engineer and Contractor, who died in or about the month of November, 1918, are on or about the 31st day of August, 1919, to send by post, prepaid, to Mr. John Alexander Fraser, of 58, Lombard Street, in the City of London, a member of the firm of Messrs. Faithfull Owen & Fraser, of the same place, the Solicitors of the Defendant Marie Marguerite Despaigne, one of the Executors of the deceased, their Christian and Surnames, addresses and descriptions, the full particulars of their claims, a statement of their accounts, and the nature of the securities (if any) held by them, or in default thereof, they will be peremptorily excluded from the benefit of the said Order.

Every creditor holding any security is to produce same before Mr. Justice Sargant at his Chambers, Royal Courts of Justice, Strand, London, on Thursday, the 16th day of October, 1919, at 12 noon, being the time appointed for adjudicating on the claims.

Dated this 2nd day of July, 1919.

DENTON, HALL and BURGIN,
3, Gray's Inn Place,
Gray's Inn, London, W.C.1.
Solicitors for the above-named Plaintiff. X 74

NATIONAL FOREMEN'S ASSOCIATION.
ENGINEERING AND ALLIED TRADES.
Registered under the Trade Union Act.

The Second Annual Delegate

MEETING of above will be held in the Middlesex Rooms at the Great Eastern Hotel, Liverpool Street Station, on SATURDAY and SUNDAY, JULY 12TH and 13TH, commencing Saturday at 2.30 p.m.—All communications should be addressed to R. W. REID, General Secretary, 31, High Holborn, W.C. 1. W 705

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and all Engineering Examinations.—Mr. G. P. KNOWLES, B.Sc., Assoc. M. Inst. C.E., F.S.I., M.R.San.I., PREPARES CANDIDATES personally or by correspondence. Hundreds of successes. Courses may commence at any time.—36, Victoria St., Westminster, S.W. 7670

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Tuition. Also Postal Courses in Mechanical Engineering, Aircraft Design and Mathematics.—PENNINGTONS, 354, Oxford Road, Manchester.

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Courses for B.Sc., Inst.C.E., Inst Mech.E., and all Technical Examinations conducted by Honours (Engineering) University Graduate and fully qualified Engineer. Fees moderate.—Address, 7676, Offices of ENGINEERING

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TENDERS.

BRAINTREE, ESSEX.

By Order of THE CRITTALL MANUFACTURING CO., LTD., who are reorganising their works for Peace production.—Messrs.

Fuller, Horsey, Sons and

CASSELL will SELL by TENDER, in LOTS, SURPLUS MACHINERY AND TOOLS, including:

A Marshall Compound Cornish Boiler, with Binnie Stoker, Feed-water Heater, and Pump.

Two 60 KW., 110 volt Steam Electric Generating Sets, with Marshall Horizontal Compound Engines.

A Compton 300 KW., 486 volt D.C. Generator.

Two 75 KW. Compton Belt-driven Generators (460 and 110 volts).

Patent Suction Gas Plant, by the Power Gas Corporation. Capacity 14,000 cubic feet per hour.

Seven Heavy Type Power Friction Fly Presses.

Three Boiler Tanks, 2800, 6000 and 7000 gallons.

40 Oil-fired Crucible Furnaces, for 300 lb. Crucibles.

14 Keith-Blackman No. 1 High-pressure Fans

A Special 150 lb. Crucible Furnace, by the Davis Furnace Co.

Three Regenerative Oven Furnaces.

Two Fletcher-Russell Oven Furnaces.

Set Hydraulic Pressure Pumps.

Hydraulic Riveter, by Berry & Co.

36 Teak finished Fire-Resisting Doors.

10 tons High-Speed Steel.

A RENNEFELT ELECTRIC FURNACE,

20 cwt. capacity, with three 125 KW. Phœnix Alternators, Switchgear, and License to use same.

The Vendors will load all Lots on Rail Free of Charge.

Tenders must be delivered at the Auctioneers' Offices, 11, Billiter Square, E.C. 3, not later than Four p.m. on TUESDAY next, JULY 15th.

Catalogues and Forms of Tender to be obtained of Messrs. FULLER, HORSEY & CO., Mechanical Auctioneers and Valuers, 11, Billiter Square, E.C. 3. (Avenue 3088.) X 143

LONDON COUNTY COUNCIL.

The Council invite

Tenders for the Supply and

DELIVERY of 2000 TONS of STEEL CONDUCTORS.

Persons desiring to submit Tenders may on and after MONDAY, 7TH JULY, obtain the Drawings, Specification, Bills of Quantities, Form of Tender, and other particulars, on application to the CHIEF ENGINEER of the Council, County Hall, Spring Gardens, S.W., upon payment to the Cashier of the Council of the sum of £2. This amount will only be returned if a bona-fide Tender is submitted. Full particulars may be obtained at the County Hall previously to the payment of this fee.

No Tender received after One p.m. on Tuesday, 22nd July, 1919, will be considered.

The Council does not bind itself to accept any Tender.

JAMES BIRD,
Clerk of the London County Council. X 66

The Government of

MALTA has FOR DISPOSAL the following PLANT, and TENDERS for the purchase of this material ARE INVITED.

(A) A Hathorn Davey PUMPING PLANT consisting of a triple expansion inverted vertical pumping engine fitted with Corliss valve gear and surface condenser, and capable of pumping 3,000,000 gallons of water per day of 24 hours to a height of 1000 feet including friction, the pumps being specially constructed for salt water.

(B) Three Babcock & Wilcox WATER TUBE BOILERS each capable of evaporating 4000 lb. of water per hour at 60° F. to steam at 200 lb. pressure and superheated 150° F.

The engine and boilers were sent out in 1909, but owing to modifications in the local scheme they have not been erected nor put into service.

Further particulars of the plant may be obtained from the CROWN AGENTS FOR THE COLONIES, 4, Millbank, S.W.1. X 37

G. R.

BY DIRECTION OF THE DISPOSAL BOARD, MINISTRY OF MUNITIONS.

For Sale, by Public Tender,

HYDRAULIC PLANT,
at CLEVELAND STEEL WORKS,
SOUTH BANK, YORKSHIRE.

Three Hydraulic Presses up to 300 tons.
Four Hydraulic Accumulators.
Four Three-Throw Pumps for above.
Air Vessels, shock absorbers, high and low pressure, Piping, Valves, high-lift Turbine Pump, etc.
Four 105 HP., 2400 volt., three-phase, 60 cycles, 600 r.p.m., slip-ring Motors and Starters.
One Switchboard and high-tension equipment complete.
One 9½ HP., 440 volts., three-phase, 60 cycle squirrel cage Motor and Starter.
Tenders close on 28th July, 1919.
For detailed list, Tender Forms and Permit to view, apply to CONTROLLER, Plant and Machinery Section, Charing Cross Embankment Buildings, W.C. 2. W 920

G. R.

SALVAGE VESSEL "RINGDOVE" FOR SALE.

THE ADMIRALTY have

For Sale, a Vessel in course

of fitting-out as a Salvage Ship.

Particulars as follows:—

Length between perpendiculars	167 ft.
Breadth extreme	32 ft.
Tonnage Register	803 about.
Present Mean Draft	8 ft. 3 in.

Composite Construction Engines Vertical triple expansion.

Indicated Horse Power	1200 estimated
Boilers	Two Cylindrical Return Tube.

Vessel is lying at Liverpool, and the present state of work would allow of her being converted for other services.

Tender Forms, with permission to inspect, may be obtained from the DIRECTOR OF CONTRACTS, Branch 8, Room 79, West Block, Admiralty, S.W. 1.

Tenders will be received up to 12 o'clock noon, on Friday, 8th August, 1919. W 888

G. R.

BY DIRECTION OF THE DISPOSAL BOARD, MINISTRY OF MUNITIONS.

NOTE.—For Detailed List of all Surplus Government Property for Sale, apply at the nearest Bookstall or to the Director of Publicity, Ministry of Munitions, Whitehall Place, S.W., for *Surplus*, price 3d.

FOR SALE BY PUBLIC TENDER.
MISCELLANEOUS PLANT,
Lying at Rainham Ferry and Woolwich Arsenal.

Tenders are Invited for the

PURCHASE, either as a whole or in part, of MISCELLANEOUS PLANT lying at above sites.

AT RAINHAM FERRY.

Keith Blackman belt driven Gas Compressors.
Reavell Air Compressor.
Tangye 50 H.P. Compound Condensing Engine.
Duplex Horizontal Gunmetal Pump, 500 g.p.h.
11 steam driven Fans, by Sturtevant.
Air Receivers, W.I. Separators.
Hand Pumps, portable Forges, Gas Meter, &c., &c.

AT WOOLWICH ARSENAL.

One Blowing Engine for 80 lbs. working pressure, steam cylinder, 18 in. by 24 in., three 38 in. air cylinders.
One 15 cwt. Platform Weighing Machine.

Tenders must be lodged not later than 10 a.m. on the 23rd July, 1919.

Detailed List, Tender Form, and Permit to view can be obtained on application to the CONTROLLER, Plant and Machinery Section, Charing Cross Embankment Buildings, London, W.C. 2. X 40

COUNTY OF LONDON.

THE LONDON COUNTY COUNCIL invites

Tenders for Paving with

ASPHALTE PORTIONS of the CARRIAGEWAYS of WESTMINSTER and VAUXHALL BRIDGES.

The Specification, Bills of Quantities, Form of Tender, &c., may be obtained from the CHIEF ENGINEER, at the County Hall, Spring Gardens, S.W., after payment to the Cashier of the Council of £3. This amount will be returnable only if the Tenderer shall have sent in a *bona fide* Tender, and shall not have withdrawn the same. The contract documents may be inspected before the payment of the fee.

No Tender received after Four p.m., on 21st day of July, 1919, will be considered. The Council does not bind itself to accept any Tender.

JAMES BIRD,
Clerk of the London County Council. X 165

G. R.

BY DIRECTION OF THE DISPOSAL BOARD, MINISTRY OF MUNITIONS.

NOTICE.—For detailed list of all Surplus Government Property for Sale, apply at the nearest Bookstall or to the Director of Publicity, Ministry of Munitions, Whitehall Place, S.W., for *Surplus*, price 3d.

For Sale by Public Tender.—

MACHINERY and PLANT at the Lancashire and Yorkshire Co.'s Locomotive Works, Horwich, Lancs., comprising—

Automatic Shell Weighing Machines, capacity 100 lbs., by Pooley & Sons.
Hydraulic Presses; working pressure, 1000 per square inch.
Double-headed Horizontal Drilling Machines, by Holroyd; diam. of spindle, 1 in.
Electro-plating Plant, consisting of 6 volt dynamo, shunt regulator, with voltmeter, &c., &c.

Together with—

Shell Boring, Recessing, and Rough Turning Lathes, Thread Milling Machines, by Oldfield and Schofield; Buffing Machines; Pneumatic Riveting Machines; Tapping Machines; Shafting (2½ in. diam.); Lead-lined Tanks; Lacquering Ovens; &c., &c.

Tenders are invited for the purchase as a whole or in part. Tenders close on the 28th July, 1919.

Permit to view and Tender forms to be obtained from the CONTROLLER, Machinery and Plant (Demobilisation), Ministry of Munitions, Charing Cross Embankment Buildings, London, W.C. 2. X 108

G. R.

BY DIRECTION OF THE DISPOSAL BOARD, MINISTRY OF MUNITIONS.

NOTE.—For Detailed List of all Surplus Government Property for Sale apply at the nearest Bookstall or to the Director of Publicity, Ministry of Munitions, Whitehall Place, S.W., for *Surplus*, price 3d.

For Sale.

Samples of those items marked with a star may be seen at D.D. 8a., 'Engineers' Store (Gallery), Agricultural Hall, Islington, and also at Room 9, 37-41, Old Queen Street, Westminster, S.W.1.

Further particulars and Tender Forms may be had on application to the CONTROLLER, Factory Consumable Stores Section, Government Disposal Board, 37-41, Old Queen Street, Westminster, S.W.1.

*SHOVELS.

Square Nose, 14 in. by 11½ in.
" " 12 in. by 10 in.
" " 12½ in. by 15 in.
Stoking Square, 13 in. by 15 in.
Round Nose.
Coal-heavers.
Crafting Tools. Ref. D.D. 8/Group/326.
The above are lying at Richboro', Kent.

NAILS.

New, but slightly rusty.
Iron Spike, 5 in., 6 in., 7 in., 8 in., 9 in., 10 in., 11 in., 12 in.
Steel cut Rosehead, 7 in. Ref. D.D. 8/Group/481.
The above are lying at Newhaven.

CROSS-CUT SAWS.

4 ft., 4 ft. 6 in., 5 ft., 5 ft. 6 in., 6 ft., 6 ft. 6 in. Ref. D.D. 8/Group/585.
The above are lying at Sheffield.

*TOOL CHESTS.

Engineers'.
Blacksmiths' and Fitters'. Ref. D.D. 8/Group/534.
The above are lying in London.

*CROWBARS

5 ft. long. Ref. D.D. 8/Group/534.
Lying in London.

*HACK SAW BLADES, POWER.

18 in. by 1 in., Fine. D.D. 8/Group/534.
Lying in London.

*TOOLS, as follows:—

Combination Pliers, 6 in. and 7 in.
Gas Pliers, 7 in. and 9 in.
Round Nose Black Pliers, 3½ in., 4 in., 4½ in. and 5 in.
Flat Nose Black Pliers, 4 in., 4½ in. and 5½ in.
Flat Nose Bright, 4 in. and 4½ in.
Screw Drivers, 10 in. overall, 6 in. blade.
Parallel Bench Vices, 5½ in. Jaw.
Hand Vices, 4 in.
Pin Punches.
Centre Punches.
File Handles.
Hammers, Ball Bearing, 1 lb., 2½ lb.
Hammers, Cross-blade, ½ lb. and 1 lb.
Hammers, Copper, 1 lb.
Three Wheel Pipe Cutters.
Lifters, Valve Spring Car.
V. Blocks.
Micrometers.

In Large Quantities.

Lying in London. Ref. D.D. 8/Group/478.
Please quote references. X 30

THE CORPORATION OF BURY are prepared to receive

Tenders for the Following

CONTRACT, in connection with the Electricity Generating Station Extension at Chamber Hall:—

CONTRACT No. 2/19—
STRUCTURAL STEELWORK.

Drawings may be seen, and Specifications, Bills of Quantities, with Form of Tender, obtained, upon application to Mr. J. AINSWORTH SETTLE, Assoc. M.Inst. C.E., Borough Engineer, Bank Street, Bury, on payment of a deposit of £3, which sum will be returned after receipt of a bona-fide Tender.

Tenders, duly sealed and endorsed, to be delivered to the TOWN CLERK, Bury, not later than Saturday, the 19th day of July, 1919. X 36

G. R.

BY DIRECTION OF THE DISPOSAL BOARD, MINISTRY OF MUNITIONS.

NOTE.—For detailed list of all surplus Government property for sale, apply at the nearest bookstall or to the Director of Publicity, Ministry of Munitions, Whitehall Place, S.W. 1., for *Surplus*, price 3d.

Cement for Sale by Tender.

About 100 tons Cement lying at Lancaster Projectile Factory, Lancaster.

Offers are invited for quantities of the above.

Tender forms may be obtained from the ARRA DISPOSAL OFFICER, Raven Chambers, Shrewsbury. X 198

For Sale by Tender, Electric

GENERATING PLANT of Sub-Station, consisting:—

Three Hornsby water-tube Boilers, rated 10,000 lb. steam per hour; insured for 160 lb. pressure, only worked four years.
Three boiler feed Pumps, with fittings.
One 250 kw. Bellis & Morcom compound Engine, direct-coupled Generator, 2850/3060 volts, 50 periods.
Three 200 kw. ditto.
One 125 kw. ditto.
The whole of steam, exhaust, and drain pipes, and valves.
5 ton overhead travelling Crane, 33 ft. space.

The above plant is ready for immediate shipment, and can be seen fixed as left off work, and will be sold in one or more lots.

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Two 218 Kw. and One 325 Kw. Dick Kerr Two-phase 2000 volt, 50 period Alternators, with Direct Coupled Exciters.
Complete Auxiliary Gear, consisting of Reavell Four-stage Compressor, driven by Direct-coupled 2000 volt, Two-phase 100 HP. Induction Motor, Marble Switchboard with Mechanical Remote Control for Three Generator and Two Feeder Panels, with the usual Measuring and Synchronising Gear; Motor-driven, Water Circulating and Fuel Oil Pumps; Heenan & Froude Water Cooling Plant for 1000 gallons per hour, Cooling Water and Fuel Oil Tanks, Fuel Oil Storage Tanks of 90 tons capacity, and a Quantity of New and Second-hand Spare Parts.
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Applications to be sent on or before July 17th, to the ACTING WARDEN, from whom further particulars may be obtained. W 971

LIGHT-WEIGHT CONCRETE.

By W. L. SCOTT, A.M.Inst.C.E.

. CONSIDERABLE interest has been created among engineers in this country in a light-weight concrete employed in the construction of reinforced concrete vessels of large tonnage building in America for the United States Government. This concrete was adopted for this form of construction after an extensive series of tests on concretes of all kinds carried out by the Concrete Department of the United States Shipping Board, under the direction of Professor F. R. McMillan. The tests proved that a concrete eminently suitable for use in reinforced concrete structures, and having a much lower specific gravity than that of ordinary concrete can be obtained by introducing an artificial aggregate having a specific gravity less than unity.

Advocates of this concrete claim that no object is gained in having a very hard aggregate possessing a crushing strength much greater than that of the concrete made from it, and as the crushing strength of the light aggregate is not greatly in excess of that of the strongest concrete made from it, this claim is fulfilled in the new material. The experiments also showed that the modulus of elasticity of the aggregate in compression approximated to that of the binding material, and the resultant concrete, therefore, possesses a relatively greater homogeneity.

It is well known that the strength of concrete depends primarily on the strength of the binding material, and on its adhesion to the larger aggregate. This adhesion is greater to a marked degree with the light aggregate under discussion owing to its greater surface area. To produce this increased adhesion a larger proportion of cement must necessarily be introduced, resulting in what is commonly known as a rich mixture, and, consequently, a more costly material. However, its adoption in certain reinforced concrete structures must undoubtedly prove economical. Large span reinforced concrete bridges and similar works, are at present severely handicapped owing to the weight of the concrete employed in their construction, and it is in cases of this nature that the light aggregate will serve to overcome this difficulty to a large degree.

On December 4 of last year a reinforced concrete vessel of 3,000 tons deadweight was successfully launched at Brunswick, Georgia. The vessel was constructed on the monolithic principle, and was cast entirely with the new light-weight concrete. The actual weight of the hull was slightly under 2,000 tons, and it was launched endways, thus imposing stresses upon the structure equal to, if not in excess of those ever imposed on engineering works of reinforced concrete situated on land. The writer was on board the vessel during the launch, and although her bottom was under a head of water of over 12 ft. no percolation whatever took place, and no cracks of any kind were perceptible in the upper or lower parts of the structure.

These results are all the more remarkable since a working compressive stress on the concrete of 1,000 lb. per square inch was assumed for designing purposes. This stress was calculated without taking into account the additional strength due to the provision of lateral steel reinforcement specially designed to increase the resistance of plain concrete, and it is much higher than the compressive stress permitted by the regulations of the London County Council for heavier concrete of the best quality.

The concrete employed in the construction of the above vessel weighed about 110 lb. per cubic foot. It was feared by some of the engineers in charge of this work that the aggregate, being so light, would tend to rise during running, but actually the aggregate distributed itself throughout the mass in a most satisfactory manner. The employment of light pneumatic hammers which were used to vibrate the shuttering during ramming, materially assisted the flow of the concrete around the steel reinforcement, and produced a dense and impermeable material.

During an exhaustive series of percolation tests on concrete carried out in this country by Lloyd's Register of Shipping, and in America by the United States Shipping Board, it was clearly demonstrated that percolation of water through ordinary concrete takes place along the surface of the aggregate, the water filtering through between the aggregate and the cement mortar forming the binding material. In the case of a light concrete, the surface of the aggregate is very uneven, and consequently its resistance to penetration by water is considerably increased. The aggregate itself, although light and cellular in structure, is not porous. The lighter quality will actually float on water, and as a test the United States Shipping Board authorities kept an amount of aggregate floating in water for some months, and it was demonstrated that the absorption was very small.

The light artificial aggregate being used in America is made from clay, calcined in kilns in a similar manner to that employed in the manufacture of bricks, the fundamental difference being that the heat (about 2,000 deg. F.) is applied in a comparatively short time of thirty hours. This relatively sudden application of heat causes the material to swell, forming a clinker. The clay may be pressed into bricks and partially dried and stacked in kilns in the ordinary manner, care being taken to provide sufficient room around the bricks for expansion during burning. The size of the brick adopted in the United States is 8½ in. by 4¼ in. by 2¾ in. During burning, the bricks run together and form a solid mass of clinker,

which is allowed to cool for about three days, in order to ensure a high degree of toughness. The cooling of the material is then completed by water which causes the mass to split into pieces suitable for handling, and it is also found that this greatly facilitates the unloading of the kilns. The material may also be calcined in cement rotary kilns, the clay in this case being pressed into lumps of suitable size.

After burning, the product is crushed to the desired size. During the operation a proportion of the lightest aggregate is reduced to dust. This, however, is used to take the place of the sand or crushed stone in ordinary concrete. By careful selection and grading of the constituent parts, a concrete may be obtained from this product weighing about 110 lb. per cubic foot, and having a crushing strength at 28 days of 4,000 lb. per sq. in.

The method of eliminating voids in the concrete and causing it to efficiently encase the reinforcements by means of pneumatic hammers, is one which seems to have received comparatively little attention from engineers in this country. Judging from results obtained in the United States, it is considered that the use of these hammers is extremely advantageous, and might well be adopted to a considerable extent. A concrete weaker to any desired degree than the above can be obtained by reducing the proportion of cement in the mixture, and owing to the greater proportion of aggregate introduced there will be a corresponding decrease in both the cost and the weight of the concrete.

The question of cost has received careful attention on the part of the engineers responsible for the employment of this lighter concrete in the United States, and although no figures comparable with those current in this country can be given, it can be stated that the advantage gained in structures, where weight is an important consideration, fully compensates for the increased cost. At the present time a number of reinforced concrete oil tankers and cargo steamers of 7,500 tons deadweight are under construction in various parts of the United States. These vessels are 434 ft. long, and the fact that all of them are being constructed with the light-weight concrete described above, shows conclusively that the responsible authorities have complete confidence in its ability to withstand the alternating stresses which will be brought on the structures when the vessels are steaming in heavy weather.

THE NATIONAL PHYSICAL LABORATORY.

(*Continued from page* 848 *of vol. cvii.*)

Metrology Department.—The cessation of the high-pressure war activity is most apparent naturally in the Metrology Department, which would probably welcome the relief, if there were not unmistakable signs in some quarters of a tendency to drop back into the old easy-going methods and to resent insistence on high accuracy as unnecessary and vexatious. The rejection of goods which exceeded the tolerance specification has involved some hardships. On the other hand articles have been accepted that would have been rejected but for the pressing urgency, and the restoration of normal industrial conditions and the removal of the restrictions on foreign competition will not lessen the needs of high accuracy.

It is to be hoped that the reorganisation of the Metrology Department will leave the Department strong and well fitted for helping industry in the ways it has made its own, namely, by research and testing as well as by instruction. The Superintendent, Mr. J. E. Sears, M.Inst.C.E., retains Messrs. S. W. Attwell, F. H. Rolt, and A. J. C. Brookes, and others, among his senior assistants, but he has lost the valuable services of Messrs. B. P. Dudding, E. M. Eden and R. Wolfenden. We were able to illustrate the new measuring machines and projection apparatus of the department in our issues of August 16, 23 and 30 last, pages 179, 208 and 221, and we shall presently notice new machines. The easy manipulation of these instruments did not fail to impress the visitors on the occasion of the annual inspection, when also the use of simpler devices of the "go" and "not-go" and calliper types for testing shells and the methods adopted for verifying the munition gauges were demonstrated. When ring gauges for screws are to be examined by means of projection apparatus, a plaster cast of the thread is prepared. For this purpose the thread is coated with a very fine film of grease, applied with the aid of a brush, before the thin paste of plaster is poured into the ring. The latter is held upright in the slot between two horizontal boards; the plaster will settle in about 20 minutes forming a segment of 60 deg. or less, flat on its upper surface; to release the hardened plaster cast from the wooden boards and the steel, the one board is given a slight twist. The plaster should be of very fine grain. This method of taking casts is used for ring gauges of ½ in. and larger external diameters; for smaller diameters the material used is dental wax, which is simply pressed into the cavity with a penknife.

Minimeter.—The minimeter for comparing slip gauges to an accuracy of one-millionth of an inch is another of the new precision instruments, designed by Mr. G. M. Eden—who recently left the Laboratory—and made in the Metrology Department for the rapid and accurate testing of gauges of the Johansson type which have for more than a year been manufactured by several firms in this country. The comparisons are made against the gauge from the Laboratory standard set. The usual type of measuring machine which makes use of a micrometer screw and divided wheel gives readings down to 0·00001 in., and it is only with great care that the difference between two gauges can be measured to that certainty; the new instrument detects a difference of 0·000001 in. and has a range of 0·0003 in.

Though roughly made, the machine gives

excellent results even in its present form. The two main parts of the machine, photographic views of which are reproduced in Figs. 3 and 4, may be distinguished as the body and the indicator gear. Figs. 5 and 6 show the body in elevation and plan. The body comprises two rectangular blocks, 1 and 2, which are fastened together by the steel strips 3, screwed across both the ends; block 1 is fixed to the base-plate 4; the flexible steel strips allow block 2 to move backward and forward through a short distance parallel to itself. The bar 5 forms a continuation of the fixed block 1 and carries an adjustable slide 6 which is provided with a plunger 7. Three steel balls 8 are soldered to the plunger face, and the tips of these balls form one measuring face of the machine; the second face is formed by a single ball 9 fixed to the movable blocks. The slide 6 can be moved along the bar 5 on the plunger 7 in its slide to suit different sizes of gauges. The reaction of the steel strips 3 when only slightly bent does not provide sufficient pressure between the measuring faces. The special mechanism provided for this purpose consists of the jointed links 10, 11, 12, 13; link 10 is attached to block 2, and link 13 to a vertical piece 14 which is rigidly fixed to block 1. Weights are placed at the junction of the links 11 and 12, the proportions of the links being such that addition of $\frac{1}{4}$ lb. to the weight 15 increases the pressure between the measuring faces by $\frac{1}{4}$ lb.

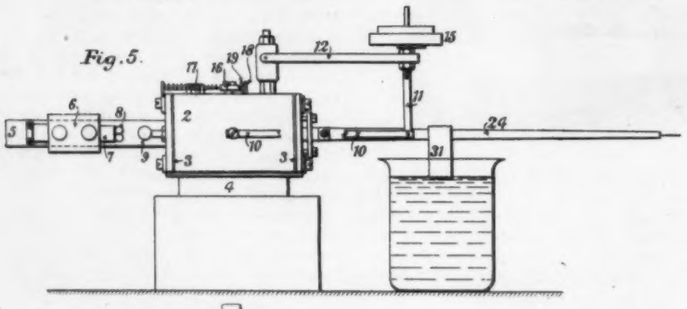
When a gauge is inserted between the measuring faces, block 2 is pushed forward by its trigger 16, which is pivoted to block 1 and presses on the pin 18 inserted in block 2. When the gauge is being held between the faces, the trigger is taken out of engagement by the spring 17 and rests in contact with the pin 18. Two stops, 20 and 21, provided with coned ends, are screwed into the block 1 and fit loosely in holes in the other block. They are so adjusted as to limit the motion of the latter block in either direction and prevent overstraining the steel strips and damaging the indicator gear.

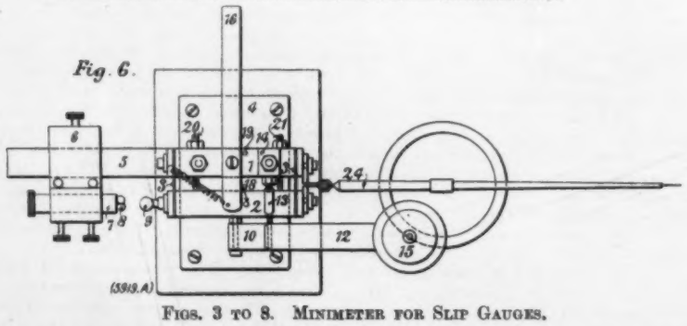
This gear, an enlarged diagram of which is shown in Fig. 7, is partly mechanical, partly optical, and magnifies the relative motion between the two blocks 1 and 2. Two small blocks 22, clamped to the ends of blocks 1 and 2, have soldered to them short lengths of very thin steel strips 23. The position of the blocks 22 is so adjusted that the strips are parallel to one another at a distance of about 0·02 in. The other ends of the strips are fastened to the end of a light tubular pointer 24, which is about 10 in. long. From the lower view, in Fig. 5, it will be seen that when block 2 moves, say to the right relative to block 1, the free end of the pointer 24 will be deflected upward in the diagram; the actual movement being in the horizontal plane. The magnification is such that a relative movement between blocks 1 and 2 of 0·00001 in. causes the end of the pointer to be deflected by about 0·035 in., that is, a magnification of 350; the magnification can be varied at will by altering the distance *d*. The pointer movement is made dead beat by providing the pointer with a thin vane, the lower end of which just dips into the water of a beaker placed under the pointer (Fig. 5). The deflection of the pointer is rendered visible and magnified by optical projection as explained in perspective by the diagram Fig. 8. The light from a pointolite lamp 25 is concentrated by a condenser 26, so as to illuminate a very fine needle 24 attached to the end of the pointer, and is reflected upward by the prism 27; the lens 28, and the horizontal mirror 29, form an image of the needle point on a scale 30 at the base of the instrument. A movement of the needle image through 0·18 in. corresponds to a relative displacement of the blocks 1 and 2 of 0·00001 in.; the combined mechanical and optical magnification is thus 18,000. On the scale 30 successive rulings indicate differences of 0·00001 in. over a total range of 0·0003 in. It should be noted that in making measurements there is no friction due to sliding contacts or movements of pivots; the movement of block 2 and of the pointer is controlled by the steel strips.

The method of using the instrument is very simple. The standard gauge is inserted between the measuring faces 8 and 9, and the plunger 7 is adjusted in the slide 6 so as to bring the image of the pointer 24 near the centre of the scale 30, and is then clamped; the scale is slid along until its zero line at the centre coincides with the image. The standard is now replaced by the gauge to be tested, use being made of the trigger 16 for opening the measuring faces. The difference between the two gauges is then read off on the scale in hundred-thousandths and millionths of an inch. The ball measuring faces have proved a great improvement on flat faces for

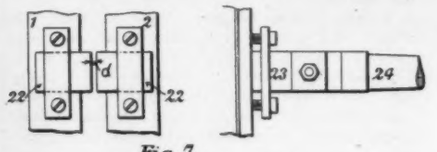
FIG. 3.

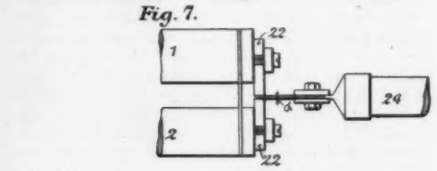
FIG. 4.

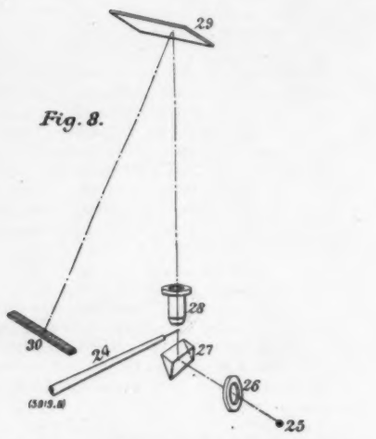




FIGS. 3 TO 8. MINIMETER FOR SLIP GAUGES.







slip-gauge measurements. The contact between the balls and gauge-surfaces is quite definite and instantaneous, even if the gauge should not be quite clean, whereas flat faces are difficult to adjust for parallelity, and the reading may creep as the gauge tends to wring itself to one or both of the faces. To prevent any contamination of the gauges by grease, &c., the pieces are handled with the aid of wooden clips. The machine illustrated has been in use in the Metrology Department since September, 1918, and it has been found possible to compare two sets of Johansson gauges excluding the 2-in., 3-in., 4-in. gauges, which are too big for the machine (*i.e.*, 81 – 3=78 pieces), to an accuracy of 0·000001 in. in about 9 hours. Three measurements are made on each gauge in turn and the work is finally repeated right through. This work previously required about 17 hours on the usual measuring machine, which we illustrated on page 179, of our issue of August 16, 1918, and the accuracy of the results was only 0·00001 in. We should add that Mr. Sears has constructed a similar machine, which is modified in several respects; his indicator is entirely optical.

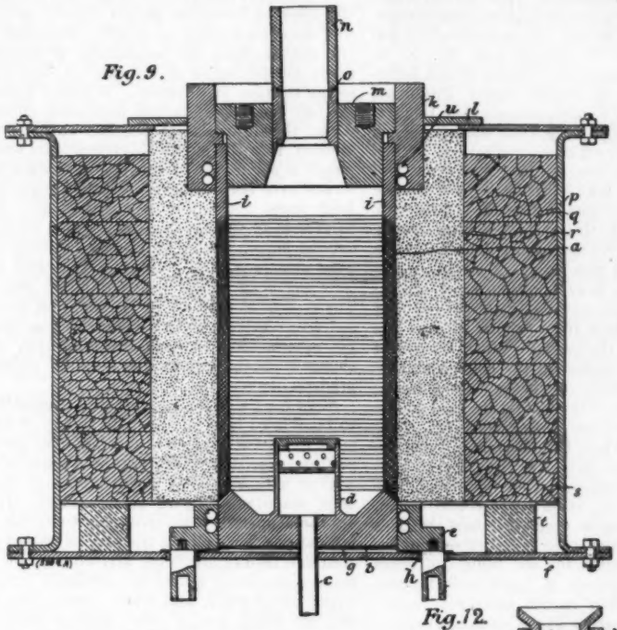
Projection Apparatus.—Another very interesting machine on view on the day of the annual inspection was the screw thread projection apparatus which Messrs. Adam Hilger, Limited, have made, on the suggestion of Mr. A. G. Cooke, M.A., the principal of the Paddington Technical School, and of Mr. Wilson, one of the officers of Woolwich Arsenal. The new apparatus, which is being tested at Teddington, shows simultaneously the profiles of both the sides of a screw, whilst in the ordinary apparatus only one side can be examined at the time.

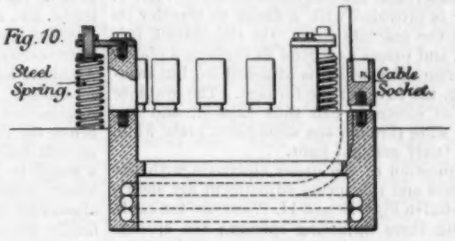
We hope to illustrate the arrangement in an early issue and will therefore at present merely indicate the leading features. The specimen under examination is placed between a pointolite lamp and two half lenses, each of which gives on the screen a shadow image of one side of the thread. If the one half lens were obscured, the shadow produced by the other lens would be black; when both lenses receive light, the shadows appear gray, and by approaching the lenses to one another in a plane at right angles to the beam, the two shadows can be brought to coincidence. When they slightly overlap, a black wavy line is seen; when they are close to one another, a white wavy band is left between the two gray shadows. If the threads are not perfect, the two images will not perfectly fit—at least not in ordinary cases—and partial black or white bands will be seen. Measurements can be made on the profiles to 0·001 in. and be compared with the measurements of the standard screw which then replaces the specimen. The apparatus, we understand, has been used in Woolwich Arsenal.

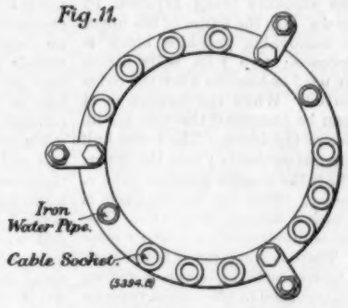
Metallurgical Department.—The staff of the superintendent, Dr. W. Rosenhain, F.R.S., has undergone little change, but is still being increased for the continuation of the researches on Light Alloys, Standards for Steel, Magnet Steels, and on Optical Glass and Refractories. The new type of Recuperative Furnace of Dr. Rosenhain and Mr. E. A. Coad-Pryor, for temperatures exceeding 1,600 deg. C. was illustrated in our issue of May 30 last, page 702. The novelty is the recuperator, which consists of a nest of tubes, made of a mixture of carborundum and a binder of china clay or fireclay, both of which must be free of any flux materials. The mode of preparation of the tubes, which have a length of 4 ft. and a diameter of 1¼ in., was explained in the paper. A carborundum wash has also been found preferable to magnesia bricks and even to zirconia bricks for protecting the walls of the combustion chamber; the wash has to be renewed after six heats, but that is easily done, whilst the spalling of the zirconia bricks, which otherwise have many advantages, causes considerable trouble. The gas furnace was designed for glass melting and for testing refractories. The high-temperature electric ring furnace, which serves for similar purposes and for metallurgical research generally, can now be described in detail; it was mentioned last year.

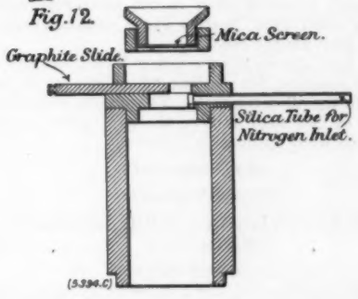
Electric Graphite Ring-Furnace.—The ring furnace of Dr. Rosenhain and Mr. B. A. Coad-Pryor, was designed to meet certain inconveniences of carbon-resistor furnaces. When the resistance is granular, the heating is liable to be extremely uneven, and liner tubes capable of withstanding the highest temperature and chemical action have to be used. Simple carbon tubes are fragile and give trouble owing to thermal expansion, and their large sizes demand inconveniently large currents. The graphite spiral avoids these drawbacks, but it is delicate to make and becomes useless if broken at any point in construction or use. In the new furnace it is not the ohmic resistance, but the contact resistance of the parts which is utilised. F. A. Fitzgerald had applied this principle in 1911 by building the arch of the furnace roof up of grooved graphite blocks, carborundum slabs serving as a lining. In the Laboratory blocks of graphite were combined to form horizontal or vertical-column heating elements; this form of construction proved inconvenient. Rings were then machined out of solid blocks of graphite and piled upon one another; the rings were first made with plane surfaces, top and bottom; subsequently they were turned conical so as to fit into one another, and these furnaces of 60 and more rings have proved successful. The resistance of such a built-up tube will depend upon the number of contacts in series and can be regulated by varying the thickness of the individual rings, the total number of rings, and the heat energy developed in different parts of the furnace. By making the rings near the ends of the furnace thinner than the other rings the "end" effect can be reduced and the region of uniform furnace temperature be extended. With increasing furnace sizes the area of each contact surface becomes larger, and large furnaces hence require undesirably large currents at low voltage. This inconvenience can be avoided by grooving the rings or removing part of the surface; the expedient would increase the local pressure, however. The contact resistance may further be augmented by contaminating the surface with a small amount of magnesia, applied as dust or as a very thin wash; too much magnesia would, however, transform the cold furnace into an insulator difficult to start. The resistance can further be varied by altering the pressure between the rings. The weight of the rings and of the water-cooled electrodes furnishes sufficient pressure in small furnaces; by means of set-screws and springs the electrode pressure can be either increased and relieved.

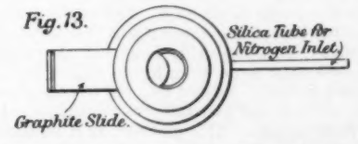
In the furnace, of 7 in. internal diameter, illustrated in Figs. 9 and 10, 60 rings *a* make up a tube 12 in. high. The graphite ring *b* is turned to form a solid bottom for the furnace; the iron tube *c* passing through it serves as gas outlet; *d* is a perforated graphite tube supporting the crucible to be heated; *e* is the water-cooled lower electrode,











FIGS. 9. TO 13. ELECTRIC GRAPHITE RING FURNACE.

a metal casting round a coil of iron pipes, seen in section in Fig. 9; the similar upper electrode is shown in Fig. 10, presently to be referred to. In order to ensure good contact between the graphite and the brass casting the graphite was at first coated with copper (by the Schoop process) and then sweated into the brass socket; subsequently the electrode was made of aluminium alloy, and as soldering was in that case inconvenient a conical fit was adopted. The metal electrode rests on the baseplate *f*, of steel, of the furnace, a plate of uralite *g* and fibre washers *h* of the same material being interposed for insulation. In the top electrode the solid graphite block is replaced by a graphite tube which makes contact with the rings (of the same diameter) and fits into the electrode *k* (Fig. 9); the latter is provided with a flange to transfer its weight to the graphite tube. On the outside *k* is machined and passes as a good fit through a plate *l* of aluminium alloy which is attached to, but insulated from, the cover of the furnace. The graphite resistor and electrode can thus expand, and the latter can slide through the aluminium plate while keeping a fairly gastight joint.

The connection of the upper electrode with the cable sockets and the spring adjustment are shown more in detail in Figs. 10 and 11. There are ten cable sockets and three adjusting springs; the springs are in compression and bear part of the weight of the upper electrode, the amounts being adjusted by the aid of the set screws. On the flange of the upper electrode rests the removable graphite block *m* which closes the furnace; two ¾ in. bolts fitting into tapped holes are used as handles when the cover block is to be removed. While the furnace is at work, the interior can be examined through a 3-in. opening in the centre of the block. The lower half of this opening widens out conically; into the upper, slightly-tapered half fits the smaller graphite tube *n*, 2 in. internal diameter, which for convenience is made in two parts with a stepped joint at *o*. The part above this joint is illustrated on a larger scale in Figs. 12 and 13. There is a cap fitted below with a mica screen, and underneath the screen a sliding shutter of mica which is pushed in when silica vapours are evolved which would condense on the window and would interfere with subsequent pyrometer observations. The cap can thus be removed without giving the air access to the furnace. Sometimes nitrogen is admitted into the furnace through the silica tube underneath the slide; in that position the gas currents help to clear the fumes away in the upper portion of the furnace. Going back to Fig. 9 we see at *p* the barrel of the furnace, a steel tube, flanged for bolting on the cover plates; the lining of mangesia block *q*; and a layer of vegetable black *r*, light finely-divided carbon, which J. A. Harker had previously used for protecting the hot graphite.

In the furnace illustrated, provided with 7-in. graphite rings, the barrel has a height of 18 in. and a diameter of 22 in. For temperatures exceeding 1,500 deg. C. the ends would get too hot with these relative dimensions; the 9-in. rings (internal diameter) are placed in furnaces 28 in. high. In the experiments on optical glass rings of 10 in. internal diameters are used, and the crucible is placed within a liner tube of carborundum to keep gases off the glass; the nitrogen introduced is first passed over hot iron to remove traces of oxygen. The thinnest rings used have a thickness of ½ in.

When the air is carefully excluded, the furnaces have a long life. The first 2½-in. rings made stood 100 heats at temperatures between 1,500 deg. and 2,400 deg. C. in a period of six weeks, and when the top rings, which were found burnt, had been replaced the furnace was as good as new. That furnace attained a temperature of 1,500 deg. in 30 minutes, consuming 8 kilovolt-amperes, and 1,700 deg. consuming 10 kilovolt-amperes, the actual current being 400 amperes alternating at 25 volts, whilst a plain carbon tube furnace would require 1,500 amperes. The 7-in. furnace requires 23 kilovolt amperes (2,000 amperes) to attain 1,650 deg. C., but the ratio of length to height is unfavourable, as was mentioned above.

Though successive series of rings are turned from solid electrode rods of Acheson graphite, the cost of the graphite is appreciable, and attempts were made to prepare rings like lamp electrodes by pressing and baking the disintegrated material. The Carbon Department of the General Electric Company at Witton, took the matter up for the Laboratory. There was, however, difficulty in obtaining sufficiently flat rings, as the carbon warped during baking and was locally graphitised and shrunk; breakages also occurred in the furnace. It is possible, however, to work with broken rings, and graphite rings are now on the market.

These ring furnaces also serve for gradient study and for testing metals under load. The furnace is then so arranged that the hottest zone is at the top, and the specimen is raised into that zone from below, by the aid of a ram mounted underneath the furnace. The arrangement offers the advantage that no parts of the suspension wires, thermocouple leads, &c., are exposed to the highest temperature.

Season-Cracking of Metals.—A problem which has been occupying Dr. Rosenhain and Mr. S. L. Archbutt for some years, is the study of the Intercrystalline Fracture of Metals under Prolonged Application of Stress, a subject which they brought before the Royal Society in April last and with which we will deal more fully on another occasion. When a metal is exposed to long-continued stress it will finally break; it may take hours in the case of some aluminium alloys, or weeks and years, but fracture finally ensues, and the fracture is not across the grain, but in the intercrystalline layer, and depends upon the condition of this layer. A smooth intercrystalline layer can bear long-continued stress; an irregular layer gives way, and acid corrosion of metals probably hastens their failure because the acid gets in between the grains. When a plate of lead is bent, cracks appear on the convex surface (tension side), but hardly on the concave surface; when strips of lead and other metals are fixed at one end and loaded at the other, they crack, even under their own weight. When Dr. Rosenhain read the joint paper before the Royal Society, he showed several specimens of alloys which had been bent and were kept bent by fixing wires round them; some of these specimens cracked whilst he was speaking. A solid-drawn tube is under continuous stress, and that accounts for the failure of brass tubes; in the hot climate of India such failures are more frequent than in the temperate zone; on the other hand, heating above certain temperatures prevents the cracking.

We may also mention a minor device, Dr. Rosenhain's machine for casting specimens which are used in the alloy research. The mould consists as usual of two steel halves; the two halves remain clamped while turning on trunnions.

(To be continued.)

RECENT MACHINE TOOL DEVELOPMENTS.—No. I.

By JOSEPH HORNER.

THE great problem of industrial reconstruction that lies immediately ahead can only be solved by increased machine production. This is the central factor—the one of first importance. Governments may hinder, or conceivably help, but the people themselves must settle down to the dogged task of increasing output. Nations who fail to understand and to act thus will inevitably be outdistanced by more virile peoples. This problem, as it confronts the captains of the engineering industry, is rendered exceptionally difficult, because, while the hours of labour are lessened, wages have increased, and the costs of raw materials and other charges go up. Yet happily it is not an impossible one. The master key to its solution is to be found in a fuller employment of machine-tools, in a large extension of their capacities, and applications. A frank acceptance must be made of the truth that industrial salvation can only be achieved by the fullest employment of the very best machines available. Only thus can the hours of labour be lessened and its emoluments increased, and capital outlay be safeguarded. This involves a clear recognition of the fact that hand-work is a factor of ever diminishing importance. Fascinating, interesting though it has been, it is doomed to extinction, replaced by the monotonous tasks of the machine-minder. Formerly, and for a long period, the machine-tool was merely a satellite, obedient to the great controlling forces of handicraft. The first milling machine was only intended to finish work previously prepared at the bench. Always, until recently, it was thought essential that skilled fitters should follow the machinists, and file, scrape and ease to get suitable contacts. To-day, except in the more massive mechanisms, efforts are strenuously directed towards the abolition of the role of the fitter, and to substitute for his work that of the assembler, the man or the girl, who, with monotonous repetition brings parts together, but who may not use a file or a scraper, or correct at all. The machine has thus become the predominant fact in production.

Some may, perhaps, be disposed to believe that the force of inventive genius applied to machine-tool economies must be nearly exhausted. When one contemplates the astonishing performances of many machine-tools at the present day, the belief seems to have justification. It would appear that the last economies possible have been embodied in these, that the highest possible output has been secured, that the greatest developments and refinements in precise self-acting, and in automatic movements have been achieved. Many people probably held these views too, five years ago. But the exigencies of the terrible war became an imperious driving force, before which conventional methods were shattered, and "other ways" and methods were schemed under national stress and strain. The results of that period remain, and the present insistent requirements for reconstruction, intensified by approaching international rivalries, and by changed labour conditions may be expected to produce like results.

Since relatively few people are so circumstanced as to be able to take an adequate survey of this now most extensive subject of machine-tool design and performance, it is thought that a series of articles dealing with the more recent advances that have been made may be of some service. It seems desirable now to take stock, so to speak, of the present position, to note the various ways by which desirable results are being arrived at, how performances are being quickened, methods crystallised where views differ, and where rival systems clash and are being fought out. Neither machine-tool builders nor users always see eye to eye on all matters. Yet satisfactory results are obtained from rival machines, methods and systems. It is all intensely interesting, not less so to those who have been associated with the shops all their lives, than to others to whom the subject possesses some aspects of novelty. It is perennially attractive, custom does not stale its infinite variety. In this preliminary article it seems well to present a précis or summary of the subject as it appears to arrange itself naturally in the mind.

The Common Basis for Machine Tools.—Machine-tools of all types, however diverse they are in appearances and functions, possess some features in common, so that it is as a closely related group, as members of one great family that we think we ought to approach the study. That which each has in common is the capacity to produce a few elementary geometric forms. The fact that these shapes can be obtained in various ways on machines that are entirely unlike each other in general design and appearance explains why so great diversity exists in the methods adopted for the accomplishment of similar results, and also why the choice of one in preference to that of another may, and often does, result in considerable economies. Sometimes, too, though not always necessarily, a finer degree of accuracy is desired and obtained. But in general a machine is capable of producing within required limits of accuracy any forms which it is designed to impart, these being graded in tools built for commercial, or for superfine work.

Present and Past Practice Compared.—Methods of tooling that are now adopted afford strong contrasts with those of a recent past. The wise machine shop manager takes broad views. He looks to results first, and regards machines as contributory to the results desired. He does not look at things from the point of view of the turner, or the planer hand, or the grinder—the "practical man" who remains in a life worn groove where he

is safe. His position is that of the organiser, whose instinct is to suspect the wisdom of crystallising conventional methods, of pursuing beaten tracks, being conscious that shorter cuts and more excellent results are to be found. There are many kinds of tools that will produce cylindrical forms, external or internal, many on which screw threads can be cut, or plane surfaces produced. Keen rivalries exist between planing and milling, between turning, boring or planing and grinding, and so on. Even when the form is the same, and the piece the same, economy often results from a separation of tasks, divided between different machines, as roughing from finishing, rough-turning from finish-grinding, rough-milling from finish-planing, boring from turning, gear tooth-cutting from tooth-grinding, screw-cutting from fine sizing. Again a vast volume of screw-cutting has been taken from lathes of the old standard design fitted with long lead screws and change gears, and transferred to turret lathes which use master hobs or leaders, or reversing or opening dies. Where change gears and lead screws are retained for long screws time is saved by the employment of nest gears, or by making rapid changes to enable more than one pitch to be cut without altering the set-up.

The Universal machines are regarded with less complaisance than they were, being mostly relegated to the tool rooms, and to the small establishments where their utilities are undoubted. In the large shops their place is now occupied by the "manufacturing" machines, having restricted functions, which renders them better suited for a large production than those designed for the performance of a wider sphere of duties. Fittings, details and movements that are not required for these functions are omitted, and greater strength and more exact adaptabilities are embodied, while refinements are eliminated when they lie outside the special scheme. Only those degrees of accuracy and refinement are included which are essential to the proper tasks of the machines. Durability, and retention of accuracy are studied as in other designs. These machines occupy a position between the older Universals, and the latest single-purpose tools.

The Elements of Machine Tools.—The statement that machine-tools of all types possess features in common has another aspect, other than that of the production of similar geometric forms. It is the aspect which embraces the main elements, of which all machines are built up. These may be likened to the vital organs that are essential to the activities of the animal kingdom. There is a necessary scheme, an outline construction general to all machine-tools, varied it is true, presenting many aspects, and modifications in details, yet readily traceable throughout the whole group. These are beds, tables, standards, slides, spindles, provisions for making changes in speeds and feeds, reversals of directions of motion, methods of driving, and of holding the work and the tools, and the very numerous devices which have for their object the delay of the wear of moving parts, and the correction of inaccuracy when it develops, all vitally absolutely essential, and recurring continually in different aspects and guises.

The correct way therefore in which to approach this many-sided subject appears to be that of the study of these constructional elements. To consider the different machines as groups and types would, it is clear entail much repetition, be tedious and somewhat conventional. So, too, would the study of the great groups of machines from the aspect of the production of the elementary geometric forms. Yet the great types, the families have so many aspects of interest for the machinist and the student that they cannot be altogether left out of the method of treatment. One cannot entirely blot out the memory of the long story of the evolution of present day tools from those of a bygone time, since archetypal forms can be traced as survivals in some of the highest and latest developments.

The Great Groups of Machine Tools.—Though, therefore, the intention is not to approach the present subject in the way of a cut-and-dried study of the families and classes of tools, yet the path will be cleared if we present here an approximately correct classification of the numerous groups into which these fall. Approximate only because so much overlapping occurs that it is not possible when tools occupy a border line to state precisely how they should be allocated.

All machine tools can be included in one or another of the general types, those in which the primary movement is that of rotation, and those where it is reciprocating. Whether these motions are imparted to the tool or to the work, or like movements to both simultaneously, or whether linear and circular motions are combined concerns only the sub-grouping of the great classes. The machine-tools in which the primary movements are those of rotation includes the lathes, the drilling and boring machines, the milling machines, including many gear cutters, and the grinding machines. The reciprocating group embraces the planers, the shapers, slotters, hack-sawing machines, keyway-groovers and some gear-cutters.

The Rotary Group of Tools.—The lathe is the oldest machine-tool. It is now the most highly specialised. The earliest form, the dead-centre lathe, survives in another great group, the cylindrical grinding machines. With the watchmaker's dead-centre tools we are not concerned. The engineers' lathe was long standardised in the fully equipped "self-acting sliding, surfacing and screw-cutting" design, with a gap bed. Occasionally an overhead was included for doing gear-cutting, and for milling the teeth of cutters, combined then with a division plate on the headstock. With this fitting the lathe was regarded less as an engineers' tool than as one suitable for the small shops, and for opticians and amateurs. A sharp division is now commonly made between screw-cutting lathes, and those unprovided with lead screws, the latter being therefore designed for self-acting sliding and surfacing only, and both groups are made with a gap, or without it, more often now without. Some have gaps of movable widths obtained by sliding an upper bed along a base—the method of the break lathe applied to those of moderate heights of centres. These two families have been prolific of many offshoots.

From the non-screw cutting group are derived the following. The large break lathes at one extreme, the small bench lathes at the other. Shaft, gun, turbine lathes. Axle lathes which have the driving headstock in the centre of the length of the bed and two loose poppets; double-headed lathes, centring, cutting-off lathes; chucking lathes, wheel and tyre, pulley lathes, vertical boring and turning mills, lathes upended, with either single or multiple tool bars, and often with turrets. Snout boring machines, boring machines using boring bars, vertical cylinder-boring machines using boring bars, multiple-head boring machines. These take their proper place in the lathe group, because they take away work formerly done in lathes of centres or face designs.

From the old standard screw-cutting lathes, the offshoots are: screw machines, both single and multiple spindle, turret and capstan lathes, using solid and opening dies, chasers and leaders or hobs. Brass-finishers' lathes with a leader screw. Bolt screwing machines, with or without a short lead screw fitted. Thread milling machines.

From the old drill press have been derived the vertical-spindle drilling machines, the sensitive high-speed machines, the radial arm group, machines with turrets, the horizontal spindle type, the numerous multiple-spindle designs and the portable tools.

The original Lincoln miller has been the parent of a large number of horizontal-spindle machines, varying greatly in dimensions and details. The pillar and knee machines came much later. These are either plain manufacturing, or have Universal capacities. The vertical spindle machines are relatively late. Gear-cutting machines which use form cutters are sub-groups of the milling type, and so more distantly are the hobbing and the screw milling machines. The plane-millers or rotary planers, and the ending machines comprise a separate group, large and varied, based from some aspects on the Lincoln design, from others on the common planing machine. The vertical spindle designs include the profiling machines, or have profiling attachments.

Grinding machines have developed along several lines from the original non-precision types. The latter are used more extensively than ever, because the sphere of grinding practice has been enlarged, but relatively they are in a minority. In some of these a measure of precision is secured by means of suitable work-holding or supporting rests, examples of which occur in many of the face and disc grinders. In other directions improvements have been effected, as in the fitting of safety guards, dust exhausting devices, float adjustments in water troughs, improved forms of bearings, better methods of wheel mounting. Precision machines include the plain, and the Universals, in which work is supported between head and tailstocks, or in a face chuck, the traverse being imparted either to the work table or to the wheel head. Related to the plain machines are grinders for dealing specially with shafts, rolls, axles, cams and other forms. Allied to the Universals are many tool and cutter grinders.

The Reciprocating Group of Tools.—The reciprocating machines are all derived primarily from the planer, subsequently from the shaper, and the slotter also. From the planer have been evolved numerous variations from the standard type that relate to removable housings, and open-side forms, with variations in the number and disposition of tool boxes, and in their designs, as revolving, reversing, tilting and side-cutting. The pit planer where the work is stationary and the tools travel is a special form as also is the side-planer. Wall planers with tool boxes having vertical and horizontal cutting movements are a sub-class. Portable machines and key grooving and horizontal broaching machines are remote representatives of this very large family group.

The shaping machine group is a small one relatively. It includes the single tool head and the double traversing head, with either uniform or quick return motions, and the small portable shapers and gear shapers or planers. The slotting machine has uniform, or quick return motion, and carries one tool or two. Tables are simple or compound. Portable machines are made.

The Tool and the Work.—In the immense array of machine-tools arranged in a big shop for the production of a few elementary geometrical forms, the designs are seen to be so diverse that the common basis of construction may not at first appear obvious on the face. But two elements are common to all. The tool in action naturally stands out a the central object. Around it the machine is designed and built. But the work being operated on exercises as large an influence on design as the tool does, since it imposes conditions on tables and their movements, on the forms of chucks, beds, grips, &c. Around the tool and the work, therefore combined, all machines are built. These conjointly control the following elements of machine tools. The framings and tables, and the tool and work-holding devices associated with these, the method of driving and control, speed and feed arrangements, systems of cutting, setting and grouping of tools, and the methods by which they can be employed in the most efficient manner.

Machine Tool Framings.—These framings reveal very marked differences from their predecessors of a few years since. It is usual for firms to call attention to "extra weight" put into them. But this does not tell the whole story of the advance made, which is added weight associated with its judicious distribution. Stresses on members are of different kinds, but there is little, if any, estimation of these made. Sections are derived from an accumulated experience, the embodiment of a mechanical instinct that is associated with the growth of a firm's practice, in the course of which the weaker elements and details are detected, and unsatisfactory fittings are improved or replaced. Framings never fracture, those of punching and shearing machines and power hammers excepted, and these are not included in our machine shop grouping. But if too weak, they bend, twist, vibrate, cause chattering and thus check or prevent the heavy cutting which is now so essential to securing a large product, imposing speeds too slow and feeds too fine on the tools. Frequently it is necessary to fit a bracing extraneous to the machine framing, as for example those which tie together the knee and the arbor support of some milling machines. In

others it is a steady arm that supports the lower end of the spindle of a vertical milling machine. Or the head of a drilling machine is made to slide down with the tool to support it in its travel.

When we compare the external aspect of the framing of almost any class of machine-tool with that of its immediate predecessors the difference is noticeable. If sections are studied the alterations are equally marked. Provisions for lubrication, and for avoiding mess from waste lubricant and chips are ample.

Included properly in the framework of machines, because distinct from the operating elements, are the numerous work-carrying portions, as tables, chucks, arbors; and the tool-supporting parts, as rests, sockets, spindles, chucks. In every one of these important developments are apparent not only when regarded by themselves, but also by the manner in which they influence to a large extent the designs of the machine framings.

Work Tables.—Around work tables and machine slides a good many recent details cluster, which partly concern modifications in their forms, partly the methods by which they are operated. Compound tables with micrometric screws afford considerable variations. The elevating knee tables of shapers, the elevating tables of some drilling machines, tables with more than one work-holding face, tilting tables, spindle slides with suitable counter balance, methods of guiding, and of taking-up wear are illustrative of many variations. The reversals of planer tables afford an extensive study, involving much varied detail. The reversals of the tables of grinding machines are precise to a line. A pause or "dwell" for finishing to a shoulder is often included. Many reversals in various tools are rendered positive by means of springs, and are locked securely.

Chucks.—Chucks which include work and tool-holding grips include four very large classes, the face and allied forms used on lathes, turret lathes and grinders, the collet chucks for turret lathes and screw machines, the drill-holding forms, and the magnetic chucks employed chiefly on face and on some edge wheel grinders.

Jaw chucks for holding work occur in a hundred shapes, many of which are recognised as standard forms, used in lathes of many kinds, and in grinding machines, each in types associated with the machine groups to which they are fitted. One feature common to most of these is their substantial character, by comparison with that of their predecessors, another is the improved facilities which they afford for rapid gripping, secure holding and exact centring. Many variations occur in the methods by which they are attached to spindle noses.

The employment of soft false jaws has also been extended. Collet chucks are employed in association with the hollow spindles and wire feeds of turret lathes and screw machines. Ingenuity is manifest in these designs with a view to secure the rapidity of their action, and firmness of grip. They are fully, or semi-automatic. They vary in the forms imparted to the collets. A marked advance has been made in dimensions, bars up to 6 in. being held. Shell work has been favourable to this growth. Occasionally blanks are inserted from the front, but the standard practice is to insert the bar from the rear, and advance it through the hollow spindle. Air pressure is in use for operating some chucks. Since collet chucks are built into the heads of the machines they have exercised a marked influence in the developments of the heads. Drill chucks have been subject to several improvements along with the increased rapidity of drilling practice. An instantaneous grip and release is now required. In some designs this is secured without stopping the spindle. Magnetic chucks are used on one group of machines, chiefly the vertical spindle grinders, and to a lesser degree on horizontal spindle piston ring grinders. They are of special utility for dealing with thin and flimsy articles that cannot, without risk of distortion, be bolted or clamped to tables. They are made in increasing dimensions and in circular and rectangular outlines to hold work singly or in groups. The machine tables can be used independently of, or with, these chucks.

Work-carrying arbors properly belong to the chuck group, because they hold and centre article by bored holes. They are employed for centring gear blanks, pulleys, bushes for turning, milling, tooth cutting, grinding. The expanding designs of mandrels are an extensive group. Arbors are also used for carrying the shell tools, the reamers and milling cutters.

Increased stresses of tooling have rendered necessary the fitting of outer arbor supports, which have different forms when the disposition is horizontal or vertical. To the same cause is due the increase in work and tool-supports. They are multiplied in the grinding machines, they assume several forms in ordinary lathe work. They occur in the vee and roller steadies of the box tools of the turret lathes. Turret holes are utilised to support the overhang of bars. Machine framings are carefully modified so as to bring the tool point as closely as possible to the work with the minimum of overhang.

Machine Spindles.—Spindles or mandrels with their tool or their work-holding devices, attachments, sockets, centres and grips manifest improvements as striking as any in machine tools. There are many aspects of similarity in these elements in machines of diverse kinds, in lathes, drilling machines, grinding machines, gear cutters, milling machines and necessarily so because a feature common to all is the provision required to delay and afterwards to compensate for wear, and provisions for lubrication for taking end thrusts, for attaching arbors or chucks in absolutely concentric relations and with rapidity.

The materials of which the spindles and their bearings are made are matters of moment, as are also the methods of designing and fitting bearings to resist radial and end thrusts, their dimensions, diameters and lengths, the question of fitting plain, or ball, or roller bearings, methods of protection, of lubrication, of taking-up wear. A vast amount of evolutionary work is apparent in this section of machine-tool growth. In a large measure the designs of heads have been modified by the growth of spindle design.

Speeds and Feeds.—The changes in practice that concern speeds and feeds which have contributed to the efficiency of all classes of tools have profoundly modified machine-tool design. The two items, speeds and feeds, are so intimately related that how to maintain their most efficient relation has been one of the biggest problems of the machinist. Numberless experiments have been made, keeping one constant while varying the other.

The point that concerns us at present is the influence of these matters on machine design. One of the most important changes has been the substitution of feeds driven independently from the speeding of main spindles. Another is the substitution of geared feeds for those of belts. One curious scheme is that of the employment of hydraulic pressure for imparting feeds. Speeds are gear-driven in a large and increasing number of instances, and a regular geometrical progression is common in place of the older unrelated jumps. When belt cones are retained and back gears, progressive speeds are worked out in geometrical ratios.

Systems of Driving.—Methods of driving have been passing through a change, chiefly in consequence of the greater duties imposed on machine tools by the adoption of high-speed work. Difficulties have arisen in connection with the use of broader belts and larger, wider cones, which have been met in four ways. By the enlargement of cone pulleys and retention of back gears. By the fitting of a single pulley and a constant-speed driving belt, with speed changes effected through gears. By the substitution of an electric motor drive and the retention of gears for speed changes. By the all-electric drive, with motor speed changes. Between these, but among the last three chiefly the design of machine tool drives is divided at present. Each imposes differences in the details and aspects of machines. In the last developments it is no longer a case of additions to existing tools, but of a remodelling that involves the entire construction. Not uncommon in the larger machines is the fitting of individual motors rated for different duties.

COAL-HANDLING PLANT AT PEMBREY.

WE give this week on Plate II, on the opposite page, and on pages 40, 41, and 50, illustrations of an extensive coal-handling plant, installed at the factory of Messrs. Nobel's Explosives Company, at Pembrey, South Wales. The power-house at this factory for the supply of steam, whether required for generating electrical energy, for heating, or for process work, and of the compressed air service throughout the works, contained under the original scheme sixteen Lancashire boilers, 8 ft. diameter by 30 ft. long, six direct-current generating sets having a total output of 3,300 kw., and three steam-driven air compressors with a combined output of 1,650 cubic feet of free air per minute. The steam pressure is 160 lb. per square inch, the electric current is supplied at a pressure of 220 volts, and the air pressure is 100 lb. per square inch at the receiver.

When the scheme was prepared in 1914 it was laid down for the factory as a whole that full advantage was to be taken of all labour saving appliances and that the plant and machinery installed for the general services was to be robust, suitable for continuous running and of well-tried types. On account of the national importance of the works, the position of the site, and the contemplated extensions to the factory, it was also decided to provide a large reserve coal store.

The reserve coal store is contingent to the main boiler-house, and therefore, when laying out the scheme for handling the coal, it was expedient to combine the equipment in order that the delivery might be made (*a*) direct from the coal wagon to the boiler-house overhead coal bunker, (*b*) from the coal wagon to the reserve coal store, or (*c*) from the reserve coal store to the overhead coal bunker, and still leave a clear way in case of a breakdown to the mechanical plant for (*d*) trucking on a portable railway or wheeling the coal into the boiler-house at stoking-floor level.

The site available for coal storage is as seen in the general view, Fig. 1, page 50, and the plan, Fig. 3, Plate II, of irregular shape, but by setting the track at an angle, provision was made for a rectangular area about 350 ft. long by 136 ft. wide, on which about 12,000 tons of coal could be dumped. It was decided to provide in the first section of the contract for a storage of 6,000 tons, with means for extension. Provision was also made for a service from the coal store to the chief auxiliary coal bunkers for process work about the factory, but this work was never put in hand.

The capacity of the overhead coal bunker in the boiler-house, Figs. 3 and 4, Plate II, is 575 tons. The bunker runs the whole length of the boiler-house and is 213 ft. long by 13 ft. 9 in. wide, with a mean depth of about 10 ft. To meet the possible intermittent deliveries of coal it was laid down that the plant should be capable of delivering coal to the boiler-house bunker at the rate of about 80 tons per hour, and at 50 tons per hour to the store The coal to be handled was slack, not exceeding 2-in. cubes, and on account of the class of fuel it was considered advisable to arrange for rotational working from the coal heap.

The scheme submitted by Messrs. Strachan and Henshaw, Limited, of Whitehall Ironworks, Bristol, was accepted. The illustrations given on page 50, and the drawings Figs. 3 to 8, on Plate II, clearly indicate the methods adopted for spreading the coal over the store, picking it up again from any part of the store by means of the grab working in conjunction with a telpher running along a mono-rail track supported by brackets on the A frames on the north side of the store, as shown in Fig. 5, and capable also of being switched on to the mono-rail track carried by the travelling bridge, shown in Figs. 6 and 7. This bridge spans the coal store as seen in Figs. 1 and 2, page 50. The running rails for the bridge are above the straight mono-rail track on the north side of the store and at ground level on the south side.

The coal, on receipt at the company's private sidings, in preferably 12-ton standard coal wagons, is run on to the rotary tippler shown in Figs. 3, 4, Plate II, and Fig. 22, page 40, and is dumped into a large concrete pit, from which it can be elevated direct on to the belt conveyor running along the top of the coal bunker in the boiler-house; or it may be grabbed out of the pit and transported on the telpher to the coal heap in the reserve store.

The tippler shown in Figs. 23 to 27, on pages 40 and 41, was constructed by Messrs. Fraser and Chalmer and is of that firm's standard rotary type. It is capable of turning over 12-ton coal wagons at the rate of from 8 to 10 wagons per hour; the rings are large enough to clear the maximum railway loading gauge, having an internal diameter of 16 ft. The wagon table is suspended by links on each side of the rings, and is placed 2 in. out of the centre. The rings rest upon rollers which are arranged in pairs, the two rollers of each pair being connected by equalising beams which are pivoted on a bearing pin as shown in Fig. 23, page 40, and Figs. 26 and 27, page 41.

The rotation of the tippler is effected by means of

COAL-HANDLING PLANT AT NOBEL'S EXPLOSIVE FACTORY AT PEMBREY.

CONSTRUCTED BY MESSRS. STRACHAN AND HENSHAW, LIMITED, ENGINEERS, BRISTOL.

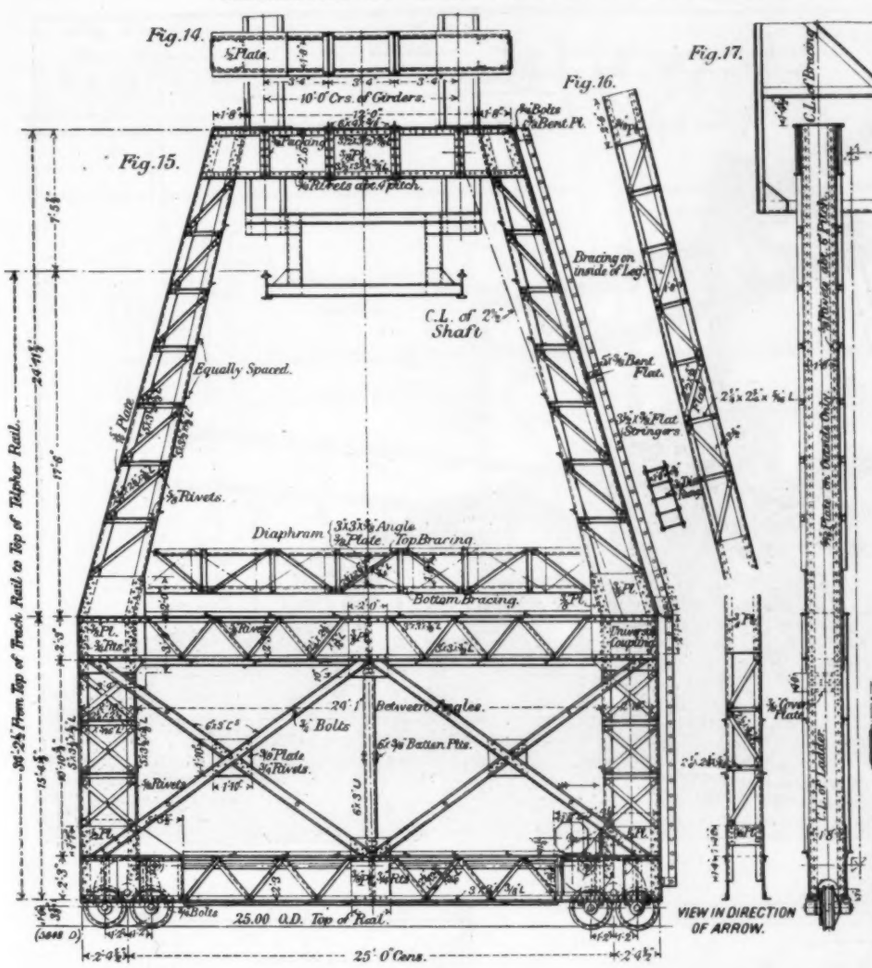


FIG. 21.

wire ropes which are anchored to the rings at the top and pass partially round them on to the special haulage gear, the drums of which are motor-driven by a 14 brake horse-power totally-enclosed traction type motor, running at 700 r.p.m. The current taken by the motor averages 45 amperes, and is on for about 2 minutes; the current consumption when making six tips per hour is about 2 units per hour.

The elevator shown in Figs. 3 and 4 is of the bucket type, each bucket has a capacity of 30 lb. It runs at 120 ft. per minute, and can deal with about 65 tons to 70 tons of small coal per hour. The motor, which is fixed at the top of the elevator, is of 10 brake horse-power, and runs at 700 r.p.m. The coal is delivered to the elevator by means of a revolving feeder, the table of which is driven from the elevator boot shaft by a chain. The coal is, on reaching the top of the elevator, directed on to the belt of the conveyor, which is 18 in. wide and runs at about 280 ft. per minute. The belt is driven by a 5 brake horse-power motor, running at 900 r.p.m. The throw-off carriage is hand operated and delivers the coal to the right and left of the conveyor belt. The consumption of power by the two motors when working the elevator and conveyor regularly, is about 11 units per hour.

The telpher, shown in detail by Figs. 28 and 29, on page 41, deals with the whole of the coal passing to or from the reserve store; it runs on the mono-rail track supported by cantilever brackets from the fixed "A" frames on to the travelling bridge, shown in Figs. 3 and 5. The telpher is a Strachan and Henshaw standard mono-rail high-speed machine, the lifting capacity is 3½ tons at 60 ft. per minute, and the travelling speed is 500 ft. to 600 ft. per minute; the hoisting motor is of 20 brake horse-power, whilst the travelling motor is capable of giving 8 brake horse-power; the motors are of the enclosed type. The controller and change-over switch for the motors, together with the operating levers, are conveniently arranged in an enclosed cabin. The two wire rope barrels were provided in order that the telpher might alternatively be used for the transporting of skips about the site.

The telpher has proved quite satisfactory, and on test was found to be capable of averaging 20 round trips per hour. When travelling with a fully-loaded grab on one-half of the round trip, the consumption of power should not exceed 6 units per hour.

The travelling bridge, Figs. 3, 6, 7 and 8, has a clear

COAL-HANDLING PLANT AT NOBEL'S EXPLOSIVE FACTORY AT PEMBREY.

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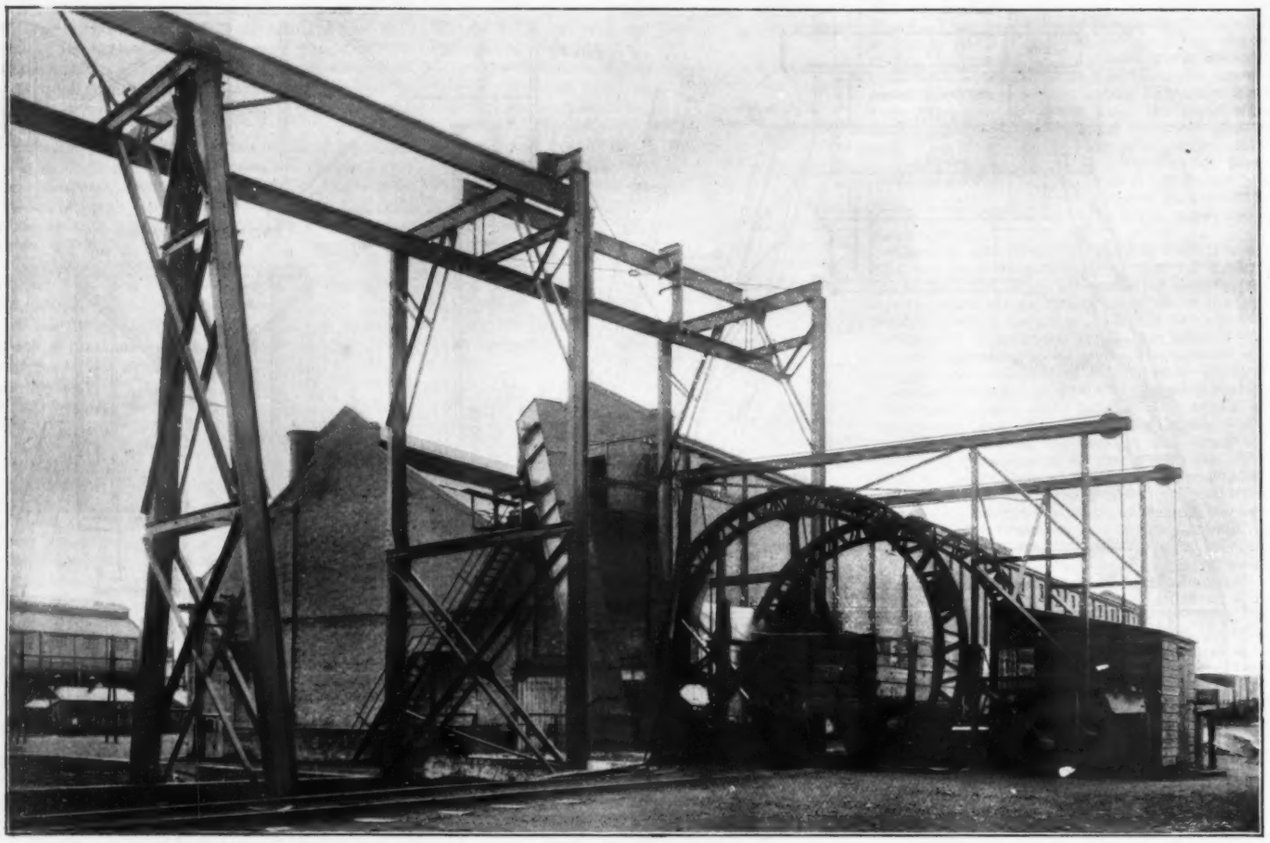


FIG. 22.

Fig. 23.

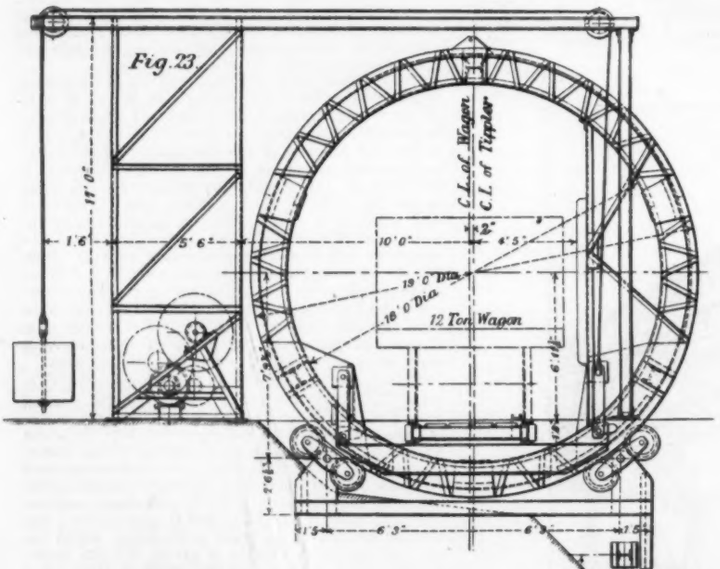


Fig. 24.

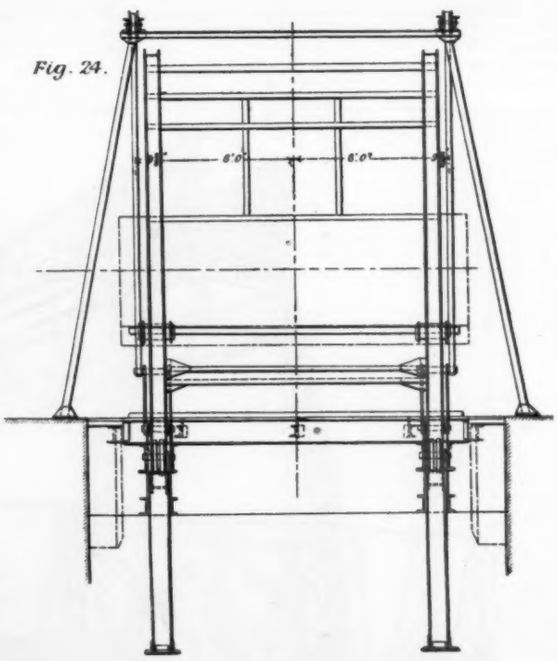
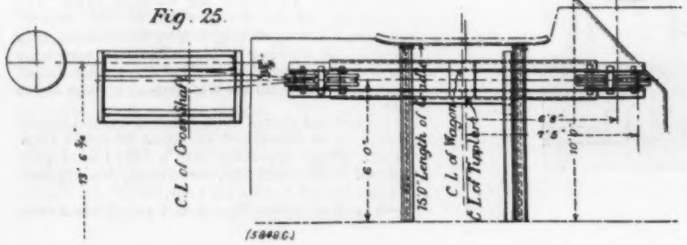


Fig. 25.



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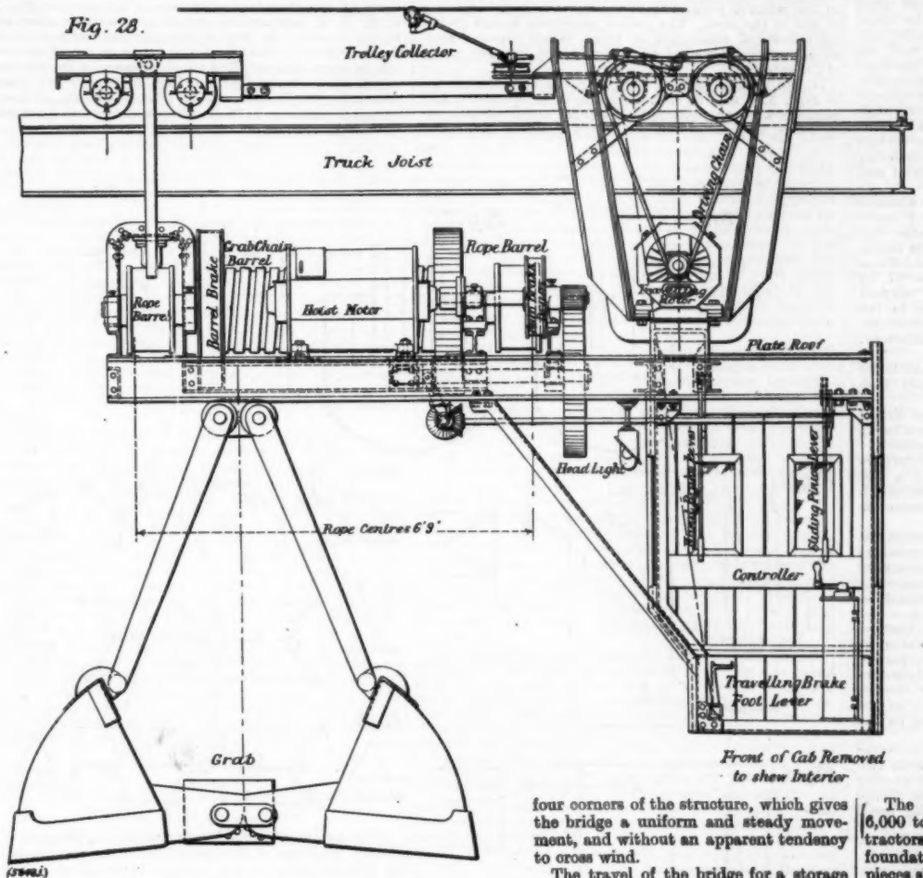
COAL-HANDLING PLANT AT NOBEL'S EXPLOSIVE FACTORY AT PEMBREY.

CONSTRUCTED BY MESSRS. STRACHAN AND HENSHAW, LIMITED, ENGINEERS, BRISTOL.

Fig. 28.



Front of Cab Removed to shew Interior

Fig. 29.

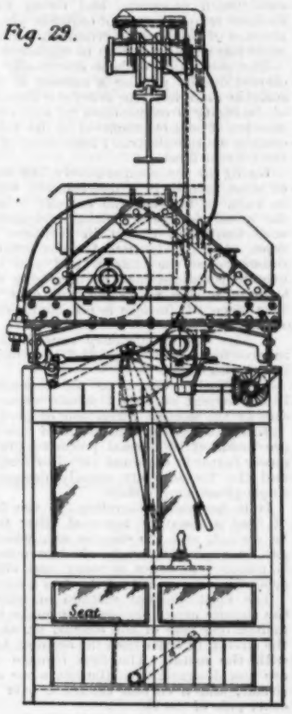


Fig. 26.

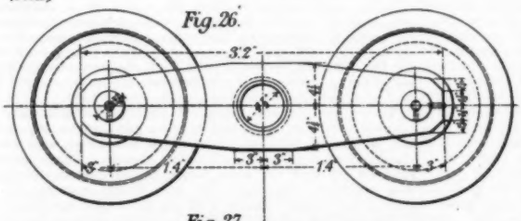
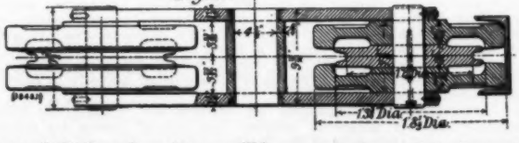


Fig. 27.



span of 138 ft. and consists, as will be seen on reference to the detail drawings Figs. 9 to 13, Plate II, of two box-lattice girders, 12 ft. deep by 20 in. wide, braced together. The travelling carriage on the north end of the bridge has a long wheel base and is fitted with four driving wheels and two outer double-flanged wheels which guide the carriage along the track; the girders at the south end rest upon pivots attached to the top of the outer leg. The bridge is thus guided rigidly at the north end and all expansion and other movements of the structure along the bridge are towards the pivoted connection at the top of the outer leg. The outer leg, Fig. 8 on Plate II, and Figs. 14 to 21, on page 39, is fitted at the bottom with a four-wheeled carriage which runs on the ground rail.

The bridge is moved when it is necessary to work on a new face or to dump coal in another part of the store, the travel is effected by driving four of the wheels in each carriage by a 18 brake horse-power motor through gearing. The two motors are coupled up in parallel and, further, the sets of wheels on the two carriages are mechanically connected by means of a 2¼-in. diameter shaft running right across the bridge. The result is that the drive is evenly distributed to the four corners of the structure, which gives the bridge a uniform and steady movement, and without an apparent tendency to cross wind.

The travel of the bridge for a storage capacity of 6,000 tons is about 140 ft., and for the additional capacity of 3,000 tons is about 75 ft., or a total travel of 215 ft.

The travelling speed is 30 ft. per minute, and the power taken to move it is about 90 amperes at 220 volts.

The grab mounted on the telpher is a "Barnard" of 35-cwt. capacity and operated by a single chain; the bucket is 6 ft. 8 in. long and the weight unloaded is 35 cwt.; a full description of this type of grab was given in ENGINEERING of ebruary 14 last, vol. cvii, page 200.

In order that the telpher may be run on either the straight through road or on to the bridge it was necessary to instal switches connecting the mono-rail on the "A" frames with those on the bridge; the track switches provided are of the ramp type, consisting of a steel slide bearing on the flange as well as upon the tread of the mono-rail, with a gradual rise within the straight portion to allow the flange of the wheels to clear the mono-rail before they cross the same to enter the curve leading on to the bridge. The ramps and switches are shown on Fig. 2, on page 50, and in Figs. 3 and 7, on Plate II, leading on to curves which have a radius of 16 ft. The auxiliary switches, by means of which the telpher passes the bridge when working on the straight-through track, are fixed in the loop and clear of the main mono-rail, which is therefore neither cut nor interfered with in any way. A full description of the switches used will be found in ENGINEERING, of March 2, 1917, vol. ciii, page 193, when a similar installation by Messrs. Strachan and Henshaw, at the Glasgow Corporation Gas Works was being dealt with. The setting of each switch operates simultaneously the corresponding frog of the overhead trolley line.

The contractors completed the tippler elevator and conveyor in September, 1916, and the telpher, with the structural steelwork, including the bridge, in December, 1916. The extension to the structural steelwork, increasing the capacity of the coal store to 9,000 tons, was carried out in 1917.

The cost of the installation for dealing with the 6,000 tons of coal, erected and started up by the contractors, but exclusive of the concrete pit and all foundations, and the coal-measuring boxes and breeches pieces shown in Fig. 4, was about 8,000*l*.

The number of men required for running the plant, assuming that the tippler, elevator, belt conveyor and telpher are all in operation at the same time, is six; but it should be pointed out that this does not include the crew on the locomotive, which should be in attendance for shunting the coal wagons on and off the tippler.

SOUTH WALES AND MONMOUTH COAL SHIPMENTS.—The Controller of Coal Mines has appointed Mr. L. Reginald Lewis to superintend and control, at Cardiff, in conjunction with the District Coal and Coke Supplies Committee for South Wales and Monmouth, the supply of coal for shipment at ports in South Wales and Monmouth. Mr. Lewis has hitherto acted as secretary of the Bristol Channel Shipping and Coal Co-ordinating Committees, which has now been discontinued.

THE RAILWAY YEAR BOOK.—This well-known publication, which is rightly described as "The Whitaker of the Railway World," makes its twenty-second appearance at a time when railways occupy a most important position among the many questions under consideration by Parliament and public alike. In the current edition the standard features that have proved most useful in the past are retained, and a considerable amount of information which was, of necessity, withheld during the war period is again included. Particulars of railway-owned steamers, docks and harbour may be mentioned as examples of this class of matter. There are 49 articles descriptive of the leading railways of the country, and to these a new one devoted to the Underground Electric Railways of London has been added for the first time. One section of the book reprints the chief Government regulations, affecting railways, in force at the time of the armistice, and among other interesting features are tables comparing the conditions in 1914 and 1918, with regard to fastest times between London and provincial towns, lengths and numbers of notable non-stop runs, &c. The "Railway Miscellany" section, introduced last year, has been amplified in the present edition, and many changes have, of course, been made in the "Who's Who" section. Generally speaking, however, the book retains its accustomed form, and one wonders whether this will be possible in the next edition. The book is published by the Railway Publishing Company, Limited, at the Offices of *The Railway Magazine*, 30 Fetter Lane, Fleet-street, London, E.C. 4, and its price is 5*s.* net.

APPLICATION OF ELECTRICAL ENERGY TO THE MELTING OF METALS.*

By H. A. GREAVES.

THE conversion of electrical energy into heat presents a number of problems differing completely from those connected with the production of heat by the usual combustion processes, and owing to the almost unlimited temperatures obtainable electrically, and the absence of combustion products, a new field of development has been opened up to engineers and metallurgists.

The generation of heat electrically is almost entirely carried out by passing a current of electricity through suitable material. As everyone knows, when a current of electricity is transmitted by any substance, a certain amount of heat is generated in the substance depending mainly on the electrical resistance of the material and the current flowing.

Owing to the comparatively low electrical resistance of most metals, it is not feasible, when melting metal in bulk, to increase the current to such a value that the metal reaches a melting temperature by its resistance loss only, except in furnaces of the induction type. The induction furnace melts the metal by resistance of the charge, and the enormous current necessary are obtained by arranging the charge in the form of a ring round the iron core of a transformer. This type of furnace is not commercially satisfactory, owing to—

1. The loss in efficiency caused by the metal being in the form of a ring, and therefore extremely high heat losses occur.

2. "Pinch" effect, or the breaking of the circuit if the current exceeds a certain value, this effect being due to the mutual attraction of parallel conductors.

3. The electrical conditions of the induction furnace are unsuited to normal power-supply circuits; a bad power factor is obtained very low frequency is required, and the furnaces are usually designed to operate on single-phase supply only.

It is necessary, therefore, to use for the generation of heat a resistant material other than the metal to be melted, and the electric arc, which is a column of gas or vapour through which a current of electricity is passing, provides a ready and efficient method of generating a very intense heat in a small space.

The most efficient method of utilising the heat of the electric arc is obviously to make the material to be melted one pole of the circuit, or, at any rate, part of the circuit, in order that the arc may be in direct contact with the metal. The first furnace using the electric arc was designed with the container as one pole of the circuit, and a carbon electrode over the metal as the other pole of the circuit.

In order to use a higher voltage and obtain a better distribution of heat, a furnace was designed with two carbon electrodes over the charge, the current passing from one electrode to the charge, and from the charge to the other electrode, single-phase current being used, as shown diagrammatically in Fig. 1.

In order to utilise three-phase currents, a third electrode was arranged over the charge, as in Fig. 2; furnaces of this kind have been very largely adopted in connection with steel furnace practice, and still form a considerable proportion of the furnaces in operation at the present time.

Without in any way attempting to deprecate the extensive pioneer work carried out by furnaces of this type, there are several inherent disadvantages, viz.—

1. The electrode currents are not independent of each other.

2. The heat is applied to the surface of the charge only, and very little circulation of metal is caused.

With regard to (1) it will be seen that if one electrode dips into the charge, or is being driven down into the charge by automatic regulation, while the other electrodes are clear, no current passes and the electrode or electrode-operating gear is liable to be broken while a molten charge of steel takes up carbon from the electrode and upsets the analysis. Many devices have been introduced to overcome these objections, but it is well known that most users experience difficulties of this kind, and particularly so when the furnace has an acid or non-conductive lining.

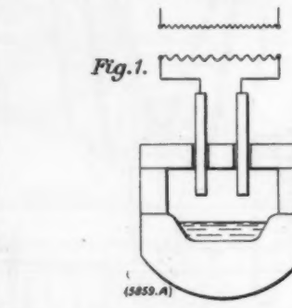
With regard to (2), it will be generally acknowledged that it is more efficient to boil water by applying a gas burner below the water than on the top surface only, as very little circulation of water will result in the latter case. This applies also in the case of an electric furnace, and it is a great advantage to introduce a method of causing the metal to circulate freely.

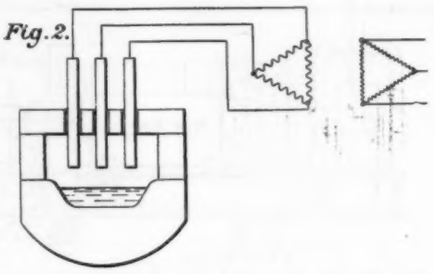
This circulation can be effected by making the hearth of the furnace fairly thick and passing a considerable current through it by using it as one electrode; it is possible in practice to apply from 8 per cent. to 10 per cent. of the total energy supplied to the furnace on the hearth alone, by using a mixture of magnesite and dolomite and grading it to give the highest resistances near the charge and a negligible resistance towards the outside. Such a hearth is as strong and permanent as any basic hearth that can be made.

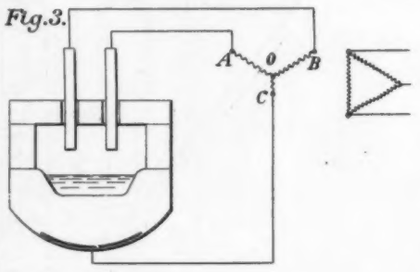
Some years ago, in collaboration with Mr. Etchells, the author discovered an electrical law which enables three-phase or two-phase current to be applied to a furnace with an unequal resistance in one of the phases and still maintain a truly balanced load as regards both power and power factor on the primary phases. The connections of such a furnace are shown for three-phase and two-phase working in Figs. 3 and 4 respectively, the length of O C being determined by the resistance of the furnace hearth.

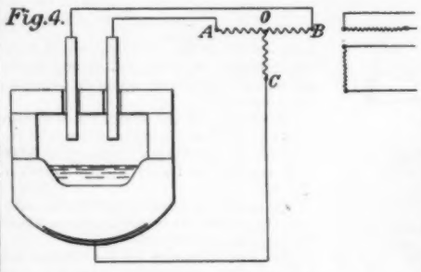
In passing, it may be of interest to electrical engineers to know that an arrangement, as shown in Fig. 5, with an unequal primary star and an unequal secondary delta connected to the furnace will give a truly balanced primary load when the two electrodes are carrying equal currents, the transformer ratios varying according to the relative resistance of the furnace hearth to that of one of the arcs. The author purposely avoids giving mathematical treatment of these rather curious electrical combinations, as they would not interest many of the members.

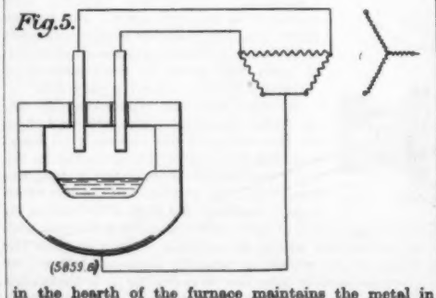
It will readily be seen that with the systems shown in Figs. 3, 4 and 5, each electrode is independent, and regulation of the electrodes, either automatically or by hand, is perfectly simple, while the heat generated

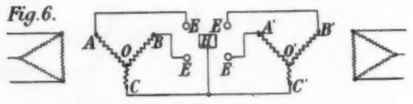


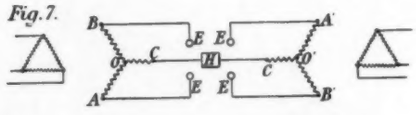


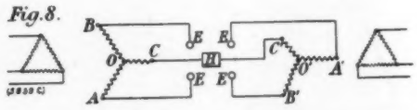












in the hearth of the furnace maintains the metal in constant circulation. These systems also give an extremely steady load on the primary phases, due to the buffer effect of the resistive hearth and the phase displacement caused by short-circuit currents.

Up till recently furnaces of the bottom-connection type have not been operated with an acid lining, as such a lining is considered to be non-conductive, although one furnace is made with a water-cooled stud in the hearth to maintain contact with the charge. Water-cooling in the hearth of an electric furnace is surely a dangerous and inefficient makeshift, and the author is pleased to say that after some little investigation a conductive acid lining has been discovered which has operated satisfactorily for some months; this invention, full particulars of which, unfortunately, he is unable to give at present, will also solve the main difficulties in regulating top electrode furnaces when operating "acid."

A number of furnaces have been built where the full load of the transformers cannot be obtained owing to the drop in power factor with an increase of current, and it has been found in practice that the full-load current per electrode on a 50-period circuit should not exceed 8,000 amperes to 9,000 amperes.

For furnaces of five tons' capacity with transformers of 1,300 k.v.a., two-electrode furnaces are satisfactory, but above that size three or, preferably, four electrodes should be used. Figs. 6, 7 and 8 show three combinations of the transformer system illustrated in Fig. 3, E, E, E, E representing the four upper electrodes and H the hearth. In Fig. 6 the current transmitted by the hearth when the electrodes are in equal adjustment will be approximately 0·7 times the sum of the currents in the four electrodes; in Fig. 7 the current transmitted by the hearth will be nil, and in Fig. 8 it will be approximately 0·35 times the sum of the currents in the four electrodes.

It is the general practice to provide tappings on the primary windings of the transformers in order to vary the voltage, usually one voltage for melting, one for refining, and one for holding the metal at a constant temperature in the furnace; it is possible, therefore, by suitably connecting the voltage-changing switch to arrange for different degrees of bottom heating effect for the different stages of each heat, the best circulating effect being necessary of course when the metal is molten and alloy additions are being made to the bath.

There are several types of electric furnace which operate with an independent arc, that is to say, an arc is formed between the carbon electrodes, and the charge does not form part of the circuit. These types are not efficient for steel melting, the output, energy and electrode consumptions, and lining repairs comparing very unfavourably with the direct arc furnaces.

For melting certain metals, however, such as bronze or copper the indirect arc furnace has certain advantages, particularly when melting metals which are volatile at comparatively low temperatures. In such a case to employ a direct arc furnace would result in a very high loss due to volatilisation on account of the very hot region of the arc being actually in contact with the metal.

By employing an indirect arc furnace this effect is somewhat reduced, but special means for cooling the walls of the furnace must be resorted to in order to prevent the refractories from fusing at too high a rate and thus render the cost of running prohibitive.

The reason for this is that the rays of intense heat from the arc strike directly on the walls, whereas in the direct arc furnace the intense heat is more or less shielded by being partly buried in a crater of slag or metal, which material, in addition to acting as a shutter, also rapidly conveys the heat away.

To render the indirect arc furnace a more commercial proposition, the U.S.A. Bureau of Mines have adopted a method of rocking the furnace in such a manner that the molten charge is constantly washing the walls of the furnace and thus the lining is kept comparatively cool. In addition to this cooling effect, the washing of the metal has a tendency to absorb some of the metal which may have been driven off as a vapour; also the charge is kept well stirred, which results in a very uniform product.

For many kinds of work the arc furnace is quite unsuitable, such as reheating, annealing or melting of metals which have low melting temperature, and even with high melting temperature, when the quantity is small.

For such work the resistance furnace is the best type that can be employed; but where the temperature to be attained is above 1,000 deg. C., the difficulties to be met with are very numerous.

* Paper read at a joint meeting of the Institution of Electrical Engineers and the Iron and Steel Institute, Thursday, May 8, 1919.

For temperatures below this figure, probably the best element is that made from an alloy of nickel chromium; but for temperatures above 1,000 deg. C., it is necessary to resort to other materials.

In the Baily furnace a trough constructed of a highly refractory material, such as silicon-carbide, is built on the inside wall of the furnace. The trough is filled with a carbonaceous material which forms the resister. The heat from the material usually travels in an upward direction and impinges on the roof of the furnace which acts as a reflector and reflects the heat down on to the charge. This seems a roundabout method of heating and is calculated to punish the roof material unduly. In addition to this drawback the carbon of the resister oxidises very readily, consequently requires frequent renewal, and thus leads to the trough being gradually filled with residue or ash from the carbonaceous material, which means periodically shutting down for cleaning.

By constant effort to improve the resister type of furnace a method of construction has been brought out to overcome some of the previous difficulties and improve the efficiency of the furnace. The method consists in forming a hearth or crucible, which acts as the container for the bath of metal, the depth of the bath being relatively small compared with the surface area of the bath. The resister element, or elements if more than one is required, are arranged suspended above the bath but as close to the metal as possible, only sufficient distance as may be required for stirring or charging being allowed. The heat generated is transmitted to the charge mainly by direct radiation.

The heating element is made of a highly refractory material, and yet not readily oxidisable at high temperatures, nor yet does the material disassociate until an exceedingly high temperature has been attained.

The element itself is built up of a number of sections dovetailed into one another and held in suspension by pressure exercised at the ends of the resister, the amount of pressure used actually being greater than that necessary to support the element; but as the resistance of the element to a certain extent depends upon the pressure, a margin of variation is allowed for.

This type of element requires no booster transformer or any extensive voltage-changing device, such as is employed in most resistive types of furnace, the amount of energy being readily varied by pressure applied to the heater unit in a manner external to the furnace.

Another feature of the furnace is that the elements are renewable even while the furnace is hot.

The construction is such as to make the furnace gastight, which results in an absolute minimum of zinc loss when employed on brass melting.

THE OSMOTIC PURIFICATION OF CLAY.*

By Dr. W. R. ORMANDY.

IT is well known that when small particles suspended in water are examined under the microscope, they exhibit a to-and-fro movement termed the Brownian movement. This movement was first observed by Brown in 1820, in certain pollen grains, and was supposed to be confined to objects which possessed vitality, but was soon found to be associated with small particles of such inert substances as silica, &c. The movement is only observable in particles having a diameter of less than 4 μ—that is, four one-thousandths of a millimetre or about 4/25,000 in.—and generally speaking is the more active the smaller the particles of silica or other material. It is even found that small crystals contained in the liquid enclosures of solid quartz are thus moving, and these must be of great age.

Thomas Graham, an English professor, first pointed out that certain bodies contained in a liquid solution can be diffused through a semi-permeable membrane placed in a vessel of water. Thus salt or sugar in solution pass through, but on treating a solution containing glue and salt it is found that the salt passes through the membrane, but the glue does not. From this peculiarity of gluelike substances, Graham used the term colloids to indicate all substances having that character. Colloid particles are comparatively large, and so cannot pass through the membrane. There are, however, differences among colloids. Gelatine dissolved in water will not pass through a membrane, but if the solution be carefully heated (at not too high a temperature) dry gelatine may be recovered, and this may be again dissolved in water; these operations can in fact be repeated several times, and gelatine is what is called a reversible colloid. On heating white of egg it coagulates, and it cannot be restored to the former condition, so it is an irreversible colloid.

Any very finely divided material, colloidal gold, for instance, can be of various sizes and colours, the colour depending on the size. If the particles of gold be less than ·1μ in diameter (1/10,000 mm. or 1/250,000 in.) they will not settle. If larger, they will settle gradually.

Clay particles will settle from water, but very slowly. On blunging (or agitating) clay with pure distilled water, and then leaving it, the coarser particles will soon fall to the bottom, and the fine clay will afterwards settle very gradually. This mode of separation is utilised in the elutriation of clays. Assuming 100 grammes of clay be thus mixed up with 200 c.c. of water, a very appreciable difference in behaviour would be noticed if hard water were used instead of distilled water.

The addition of 5 c.c. or 6 c.c. of a 10 per cent. solution of alkali (caustic soda) to a kilogramme of clay mixed with water makes the resulting slip thinner, and it settles very much more slowly than when no alkali is present. Addition of a very little salt solution causes the particles to flock together rapidly and settle down.

Bliss, in 1895, observed that the Brownian movement of a clay suspension in distilled water was accelerated by a very small addition of alkali, and was retarded again by a further small addition of alkali. These discoveries remained for a time without application. Weber used alkali for casting, but merely to make the slip thinner, with less water, and with no notion of separating the constituents.

Count Schwerin first made practical application of the conversion of suspended clay from the "gel" (or jelly) state into the "sol" condition by alkali. (The "sol" condition is as nearly like a solution as an insoluble body in water can be.) If two plates, respectively positive and negative, be placed in distilled water on opposite sides of a porous diaphragm, and an electric current be passed through the water, the water goes up on one side of the diaphragm and down on the other side. If fine capillary tubes be used instead of the diaphragm, the water will pass through the tubes, and if such tubes were lined with sulphur, the water would move in the opposite direction; the direction of motion thus depends on the nature of the lining of the tubes. Such movements constitute endosmosis.

Count Schwerin applied endosmosis to a very colloidal peat containing 95 per cent. of water, using a sieve with wooden sides and fine brass wire gauze bottom, strengthened by a perforated iron plate or stout wire netting. It required pressure to force the slimy peat through a lawn of 60 meshes to the inch, but on placing a thin iron plate on the peat and passing a current from this plate to the gauze, water at once began to fall through, and in 20 minutes the 4-in. or 5-in. layer of peat slime became a dry hard layer about ¼ in. thick. The peat at the bottom acted like a collection of capillary tubes, the water being pushed through by the action of the current. Count Schwerin took out patents, but further experiments and large scale tests showed that the process as applied to peat was not quite profitable as a commercial proposition. In the course of the experiments, Count Schwerin noticed that under the electrical treatment there was evidence of separation of some of the constituents of the peat. This suggested further tests with clay slip.

On subjecting clay slip to the same treatment, after standing a short time to let dirt fall down, it was found that the clay collected on one of the poles, and even partly dried though it was under the surface of the water. Very soon it was discovered that all clays did not behave thus, and Count Schwerin concluded that only a charged particle will move in an electric field. In some cases the addition of a little alkali caused clay to move which would not move without the addition, but this treatment did not always answer. He next tried the addition of organic colloidal matter, such as humic acid. This enabled the particles of clay to pick up alkali and also an electric charge.

The apparatus for treating clays consists of a wooden trough, lined with, say, wire gauze, and a metal drum rotating slowly in the trough, the clay slip with alkali being run in between. An overflow is provided for discharging impoverished slip. The gauze and drum are connected with electric poles, and the current is started. Clay settles on the drum, and is removed drier than it would come from a filter press worked at a pressure of 150 lb. per square inch. A ball clay will thus come off with only 17 per cent. or 18 per cent. of water, so dry that it cannot be pugged, though in an ordinary filter press it could not be brought down to 40 per cent. of water.

The thin skin of clay particles forms a collection of capillary tubes, and the clay is dried as well as collected.

How does this treatment lead to purification of the clay? Most substances when placed in water—among them nearly all clay particles—take on a negative charge, silica particles taking a much weaker charge, so that they are practically neutral. Pyrites and iron oxide particles are electropositive. Whenever a colloid particle has its charge neutralised it attaches itself to the next similar particle, and this result follows the addition of the correct (exceedingly small) amount of alkali. On the other hand, similarly charged particles (positive or negative respectively, but mostly negative) moving about may approach one another closely, but they still mutually repel. Around every particle in water there is probably a little sphere of water. The addition of a very little alkali neutralises the charge on some particles, which then stick together and tend to settle down sooner.

One hundred grammes of clay mixed with 100 c.c. (or grammes) water gives a thick, heavy slip with comparatively large particles of clay, through which the dark pyrites, sand, &c., cannot pass. By using—as at the China clay mines—97 tons of water to 3 tons of clay, and leaving the thin slip to settle, the mica and sand have a chance to settle out.

On a works scale, clay is mixed in a blunger with a little alkali (or alkali plus colloid, if necessary), in order to neutralise the charges on one lot of particles, and increase the charge on others, and so produce the sol state. In settling tanks the coarsest particles settle in a short time, it may be 5, 10, 15, 20, or perhaps 30 minutes according to what it is desired to eliminate. Then the upper part of the liquid containing the clay is run into a second tank and left to settle a longer time, the exact period depending on whether the very finest silica and impurities are to be removed or not.

In the case of a Potteries clay, containing only 50 per cent. of clay substance, with much pyrites, 5 minutes' settlement served to remove much of the pyrites and coarser sand, then a further 30 minutes' settlement removed the medium and fine sand. This second settling furnished quite good material for making grog for saggars, &c. After purifying the clay by settlement, it is run through the osmosis machine.

In the east of Germany, three osmosis machines were used for a very plastic ball clay which had previously been used as part of a mixture for making drain pipes. Pyrites was present in particles from the size of a fist down to impalpable powder, and after treatment the pyrites constituted 10 per cent. of the sales. The osmosis machine eliminated also some very fine pyrites.

Dr. Ormandy related how he came to be interested in the question through seeing samples of treated and untreated clay about nine years ago. He went to Frankfurt, and during three months stay in Germany the inventor (Count Schwerin) gave him every facility. Afterwards an English syndicate was formed, and nearly 100 English clays were tested and reported upon, some thousands of pounds being expended. As English clay producers failed to show sufficient interest in the process, the German company took steps (as the only way open) to acquire clay properties, but the war intervened.

Some eighteen months ago the Optical Department of the Ministry of Munitions required certain highly refractory articles with other special properties, and Dr. Ormandy was able to supply raw material produced on an experimental scale, which met the requirements. This led to the formation of the present Osmosis Company, and a machine apparently much better than the last German machine seen by Dr. Ormandy has been developed.

The product separated by the treatment is recovered in a comparatively dry state, it always possesses increased plasticity, it sinters at a temperature which may be as much as 300 deg. C. lower than that of the original clay, it shows a greater contraction, and it has always a higher melting-point. The value of these changes can easily be appreciated, especially in the ceramic and refractory materials industries.

* Report of a lecture delivered at Middlesbrough at the meeting of the Refractory Materials Section of the Ceramic Society, on May 23.

CHEMICAL EMPLOYERS AND ROAD TRANSPORT.—The Chemical Employers Federation has just entered into an affiliation agreement with the Motor Transport Employers Federation in respect of those of its members who employ commercial motor vehicles. The Motor Transport Employers' Federation is one of the three employers' organisations represented on the Joint Industrial Council for the road transport industry, of which council, Captain F. G. Bristow, 83, Pall Mall, London, S.W. 1, is the secretary for the employers.

PERSONAL.—Owing to the death of Sir Boverton Redwood, Bart., Mr. Arthur W. Eastlake and Mr. William Sutton, who have been associated with him for the past twenty-eight and twenty-three years respectively, have arranged to enter into partnership for continuing inspection and advice on all matters in connection with the petroleum industry. Mr. Robert Redwood has kindly consented to co-operate with them, to give them the benefit of his experience, and to undertake the examination of oil samples, &c. They will also be assisted by Mr. W. H. Dalton in geological matters, and by other gentlemen previously associated with the late Sir Boverton Redwood.—Messrs. John Birch and Co., Limited, export engineers, of London, announce that they have undertaken the overseas agency of William Beardmore and Co., Limited, the well-known Glasgow engineering firm. The Beardmore workshops are rapidly being converted from war to peace production of metals and machinery for distribution throughout the world. The Birch organisation is being further extended to meet these new requirements.—We are notified that Mr. G. W. Cosby, the Northern District representative of the Westinghouse Brake Company, Limited, for the sale of Westinghouse-Morse "rocker-joint" chains, has now been demobilised, and has re-opened his offices at Standard Buildings, City Square, Leeds.—We are informed that the Skefko Ball-Bearing Company, Limited, are opening a branch office at 14, Temple-street, Birmingham. Mr. G. I. Francis has been appointed district manager.

VANADIUM AND LEAD FROM VANADINITE.—Practically all the vanadium used in the United States is obtained from three minerals, the patronite of Peru, the roscoelite of Newmire, Colorado, and the carnotite of Utah and Colorado, and the former two sources are each controlled by one company. An attempt was made in 1910 to smelt vanadium from the vanadinite of Sierra County, New Mexico, but it was soon given up. Recently vanadite has been mined at Kelvin, Arizona, and vanadite mines having also been found in other States, J. E. Conley, of the United States Bureau of Mines has worked out a process of extracting lead and vanadium from this mineral. The analysis of the concentrates which he gives in *Metallurgical and Chemical Engineering*, of May 15 last, mentions about 54 per cent. of PbO, 12·6 of V_2O_5, in addition to smaller percentages of the oxides of iron, molybdenum, aluminium and calcium, and about 17 per cent. of insoluble residue and 5 per cent. of undetermined constituents; there is no mention of chlorine, whilst vanadinite is supposed to be $Pb_5V_3O_{12}Cl$. The metallurgical process proposed by Conley is fusion of the vanadinite with caustic soda, soda ash and enough charcoal to reduce the lead; elutriation of the slag; precipitation of the sodium vanadate by slaked lime, decomposition of the calcium salt by boiling the solution with diluted sulphuric acid when the brownish pyrovanadic acid $H_4V_2O_7$ is precipitated; part of the vanadium remains in solution when lime is added, and from this part molybdenum is precipitated by calcium sulphate in neutral solution. The final recovery of vanadium pentoxide is said to reach 85 per cent. and even 90 per cent. About 800 lb. of caustic soda and 200 lb. of soda would be required per ton of concentrates.

INDUSTRIAL NOTES.

SIR AUCKLAND GEDDES announced last Wednesday that the Government had decided to raise the price of coal to the consumer by 6s. per ton as from the 16th inst. Great interest attaches to the discussion of this question which is to take place in Parliament on Monday next.

The Liberty and Property Defence League, 25, Victoria-street, Westminster, has issued a pamphlet on Private Enterprise *versus* State and Municipal Monopolies, from which we take the following two paragraphs:—

"To the question, 'What has private enterprise done for the world?' the answer is: 'Everything that has been worth doing, and which has proved worthy of being done.' To the question, 'What has the State done?' the answer is: 'Nothing but make excuses for its own blunders.'" Private enterprise has made civilisation. By those who regard civilisation as "a curse" private enterprise is naturally abhorred. But those who rejoice in the great facts of modern life and who appreciate man's conquest over so many of the rude forces of Nature, regard it as beneficent; and to these, the vast multitude of the intellectually developed peoples of the earth, the prospect of a reversion to the social slavery of the Dark and Middle Ages is not one that appeals to the sense of the fitness of things, since it implies the reforging of fetters from which they have long shaken themselves free.

"The future of Great Britain depends upon the freedom of its industries, trade and commerce from the restraining power which 'elected persons' in Parliament or the municipality are seeking to exercise to the national detriment, and upon the maintenance of those ever-varying conditions that are essential to true and continued progress. Without the spur of private enterprise to that constant activity upon which its very existence depends, the nation, under State and municipal monopoly, would soon sink into a lethargy from which there would be no awakening. With a perfectly free initiative those two agencies known as capital and labour are capable of winning yet higher laurels of fame. Let those who have the best interests of their country at heart see to it that private enterprise has that fair play which is its merit and its due, and always bear in mind what has been called 'the great truth, that one main condition of the prosperity of the people is that its rulers should have very little power, that they should exercise that power very sparingly, and that they should by no means presume to raise themselves into supreme judges of the national interests, or deem themselves authorised to defeat the wishes of those for whose benefit alone they occupy the post entrusted to them.'"

A meeting of the shareholders of the Powell Duffryn Steam Coal Company, Limited, was held on the 1st inst., when the chairman, Mr. Joseph Shaw, K.C., made a very interesting speech dealing with the coal industry in general, the business of the company, and the reports of the Coal Commission.

In the course of his statements Mr. Shaw said it was common knowledge, and had been referred to even by State officials themselves, that management by State officials could never be so efficient as management by those men who had the incentive and the desire to succeed, and whose ambition and object was to make the greatest success of whatever they put their hands to. State officials, on the other hand, only tended to multiply and always endeavoured to shirk responsibility or to try to place responsibility on others.

Mr. Justice Sankey went out of his way to drag in nationalisation in his first report, and admitted, in paragraph 13, that no sufficient evidence had as yet been tendered on the point. As a matter of fact, at that time, the coal owners were only asked to tender evidence on the question of hours and wages, and that was all they endeavoured to do.

The first recommendation in his second report is that Parliament be invited immediately to pass legislation to acquire royalties for the State, paying fair and just compensation to the owners. Here, Mr. Shaw remarked that a very large number of colliery companies had bought the freehold minerals which they worked; why they should be compelled to transfer these minerals to the State he could not see. Mr. Shaw also dealt with other points of the second report and with the coke and by-product industry.

The Prussian State, for the purpose of their railways and in order to be independent of the Westphalian coal "ring," purchased a group of collieries in Westphalia. In a short time they turned this profitable concern into a heavy loss. The working of State-owned railways in France could not bear comparison with that of the privately-owned ones. With all these facts available, he failed utterly to see how Mr. Justice Sankey and other people could recommend this country, especially at the present juncture, to go in for such a gigantic experiment as nationalisation of the coal mines.

Speaking on the 3rd inst., at the twenty-third ordinary general meeting of Callender's Cable and Construction Company, Limited, the chairman, Sir J. Fortescue Flannery, Bart., M.P., M.I.C.E., said that the scientific branch of the company's organisation had been very busy during the war. Many problems arose, and had to be solved by experiment and research; they had a laboratory and an experimental department which was second to none in the electrical trade, and most valuable discoveries were made in connection with problems put to the company by the Government. Some at least of those discoveries would be useful to the company in the future. Many improvements had been made in detail, one of which was that they were now beginning to manufacture a cable of an extremely high voltage, which would be an economy to those who used it, and if it were successful, as they were confident it would be, it would increase the demand for electrical appliances for most practical commercial purposes. The obvious advantage of this high tension cable was so clear that they already had more demands for it than they could possibly meet, and they had booked orders which would be very profitable to the company in the future.

They had still to contend with many difficulties arising from war conditions. Transport was as hard to deal with as ever, but he was hopeful that the new Ministry of Transport would be a very valuable help to commercial people like themselves, in organising and co-ordinating the whole of the transport services of the country. Prices of raw materials showed little or no sign of being reduced, but the increases, to the best of their ability, they had to pass on to their customers. This they were doing in a fair and equitable manner, not seeking to take any undue advantage of the circumstances.

But perhaps the greatest difficulty of all that stared them in the face was the great increase in wages. The question of international competition was the one that would govern wages in this country, especially in trades like their own, far more than any supposed greed of gain on the part of the employers. They had to compete with other countries where labour was exceedingly cheap, and where, as in America, the diligence of the workers was assisted very much by their sense of the spirit of competition. The continuous use of machinery and the desire on the part of the workers to give some return for the increased remuneration, would be the salvation of this country as a manufacturing country.

The text of the Coal Mines Bill to amend the Coal Mines Acts of 1887 to 1914 with respect to the hours of employment below ground, was issued last Tuesday. It provides, among other points, that as from the 16th inst., the miners' maximum legal working day will be reduced from 8 hours to 7 hours.

Last Monday there was held at Cardiff a special delegate conference of the South Wales Miners' Federation, to arrange the new shifts in connection with the 7-hour day. It was tentatively agreed that there should be uniformity of shifts throughout the coalfield. That on Monday the shift should be from 7 a.m. until 2 p.m.; on Tuesday, Wednesday, Thursday and Friday, from 7 a.m. till 2.15 p.m.; and on Saturday, from 7 a.m. till 1 p.m.; one extra quarter of an hour on four days being put in so that there should be a shorter day on Saturday. For the afternoon shift the hours arranged were from 2.15 p.m. till 9.15 p.m., and for the night shift from 11.45 p.m. till 6.45 a.m.

This bringing down of the working hours from 8 to 7 means a reduction of 12½ per cent. in the working time; and as the piece-workers stand to lose by this reduction, they demand an addition to the piece rates, as stated on page 15 *ante*. The matter was looked into at Monday's conference, and it was decided finally to submit it to the Miners' Federation of Great Britain.

It is reported that the South Wales miners are now asking for extra payment for week-end work, a claim which the Coal Controller has placed before the Ministry of Labour.

THE CONTROL OF SHIPS' STORES.—The Board of Trade, in conjunction with the other departments concerned (Admiralty, Ministry of Food and Customs), have withdrawn, after June 28, the control exercised hitherto over the shipment of provisions and other ships' stores on British, Allied and neutral ships at ports in the United Kingdom. This control was a part of the "blockade" as well as a measure to conserve supplies here during the war. The ship store dealers at the ports will therefore be under no restriction, other than their difficulty in getting unlimited supplies, in the quantities of food-stuffs and other ships' stores they sell to ships in British ports. This completes the withdrawal of control which was begun on April 1 last. The temporary staff for control of stores, which was largely reduced in April, is now being entirely demobilised.

ENGINEERING TRAINING FOR DEMOBILISED OFFICERS.

TO THE EDITOR OF ENGINEERING.

SIR,—With reference to the letter from "B.Sc." in the issue of July 4, page 24, I, like many others, find myself in a position somewhat similar to his, except that I have had a few months experience on works; this was before the war.

Notwithstanding this, and in spite of the positions of responsibility and trust I held while in the Royal Engineers, and the execution of some bits of real structural engineering work, up till now I have been unable to get employment, and therefore would welcome a scheme such as has been started by the "well-known electrical engineering firm."

I have tried very hard to get a vacancy, but to no purpose, because wherever I go I am told that I have not had sufficient practical experience. That may be, yet I feel quite capable of tackling anything which a junior assistant engineer is called upon to do. I sometimes ask myself "did I not gain *any* experience while in charge of a big sawmills and workshops for nine months"; did I not carry out faithfully the construction of an aerodrome and its collateral works for two Handley-Page squadrons"; "did I not erect some enormous steel structures—according to plan—in the erection of which I had a number of British ironworkers (civilian) under my direction"; in short, "was I of any value at all to the Army?" Engineers and contractors may contend that I was wasteful. I probably was; at the same time, they cannot but admit that I did have a certain amount of practical constructional experience. Lastly, I ask myself, "are two testimonials of my engineering ability, voluntarily given me by two corporate members of the Institution of Civil Engineers, of any value?"

To several firms I have offered my services for nothing, as they had businesses in which I was specially interested in, and in which I had made myself efficient theoretically—and merely desired to be given a few practical hints, when I am sure I would be of value. No, Sir, they want a man with previous practical experience—in other words, a stay-at-home man. I say this advisedly, as there has been little (if any) "big work" done in ferro-concrete, the particular line in which I am interested, in army areas.

Can you wonder that many of us are faced with the necessity of abandoning the engineering profession? It is very galling to think of the fact that these years of service, given at a critical period of one's career, show nothing on the credit side of one's personal account.

It is certain that employers do not realise the fine material they could work on and shape when they do not give a chance to men like "B.Sc." and others in a similar position, myself included.

I am, Sir, your obedient servant,

July 8, 1919. "B.Sc. (1915)."

"THE CONDITION OF ENGLAND, 1919."

TO THE EDITOR OF ENGINEERING.

SIR,—Between diseases of the body politic and the body corporate there is an obvious distinction. While it is seldom wise to allow the sick man to know the gravity of his case, to the sick nation that knowledge is necessary for its recovery. For almost all diseases of the body politic are curable, and only curable, by the body's own efforts. In some cases the knowledge has come too late, as possibly it has in the case of Germany, infected by a disease she failed to recognise. England has for some time exhibited symptoms which are not those of health. Believing that their gravity is not generally realised, I propose to describe one or two of them in some detail, leaving their treatment, or, better, the treatment of their causes, to suggest itself to the people concerned. Now, there are few conceivable circumstances in which it is wise to ignore facts and almost as few in which it is wise not to admit them.

To-day is not the time to pursue the policy our Press pursued during the earlier days of the war—the policy of invertebrate optimism, which glossed over our defeats, magnified our victories and dwelt, not on dangers present and to come, but on our innate, national superiority to the Germans and its certain effect in the near future. That policy, unjustified then, would be ruinous now.

I may, as a preface to my remarks recall one item of the Press propaganda of the earlier days. The popular mind was diverted from the contemplation of the serious situation in France and directed to the coming Utopia in England. There would be, above all things, an end to industrial strife. The workman, in whose hand the war had placed the most powerful weapon he ever held, was, by some process of reasoning never yet disclosed, to see the merit and wisdom of doing more work for the same money for his ancient enemy, the master; who, in his turn, as a result of having been ruled for some years by the men, should see the desirability of paying more money for less work. In short, when peace should come we should enjoy all the benefits of Socialism, without those unpleasant folk, the Socialists. With such encouraging matter did the majority of our newspapers soothe the nervous section of the public and irritate the more thoughtful. It would be idle, as it is unnecessary, here to discuss the wisdom or folly of it. We no longer read articles of that tenour.

Let us consider the facts of to-day. The majority of works have few orders beyond those in hand, and have little present prospect of obtaining more. Our foreign customers can either afford to wait for the fall in our costs which they hope for and we see no means of achieving, or can buy more cheaply abroad. Our workers have during the last few years been promised, by people who will not directly be called upon to produce it, a reconstruction of society—improved conditions of living,

education and of everything desirable. Not unnaturally they are now doing their best to obtain for themselves these promised advantages which no one else seems acutely anxious to give them. The expression of their desire for "better conditions" takes the only form we could rationally expect them to give to it, and that is the form most dangerous to this country—less work for the same or more money.

A word is here necessary upon a vexed and controversial subject. The life and death of nations is one of extraordinary complexity and is one from which many of our great men, pre-eminent in science, have recoiled. Huxley was not one of these, but he averred that his own subject of biology was of relative simplicity in comparison with that of sociology. But if, in reviewing the progress of civilisation, we look backward we see the road it has come strewn with the debris of nations which have gone astray, transgressing the laws they did not comprehend. I am not proposing to step in where great men have refrained from adventuring themselves, but I must, before proceeding, enunciate two axioms of the greatest importance to us in England to-day. I hope they may find general acceptance :—

1. The greater part of the food eaten by the inhabitants of this country is imported.

2. This imported food is paid for by exports, principal amongst them being coal.

These two statements being agreed upon, what is the implication? No one is ignorant of the complexion of our trade returns, or the future of this country if that complexion does not soon improve. It may be left to financial experts to decide how long the bleeding process we now endure could continue before death would supervene. The ordinary man lacks the knowledge, and usually the will, to compute it; he generally soothes himself with the expectation of the coming boom that is on all hands declared to be inevitable.

It is because I cannot share that expectation that these lines are written.

Consider the prospects confronting the engineering trade. The workers have been lauded to the skies for their energy and skill and the abandonment of their trade-union privileges during the war, and have been told from every Government platform that the old working conditions are gone and a new era has set in. It would be profitless to inquire what the politicians meant when they made these promises, because, without impugning their good faith, we may reasonably doubt their ability to fulfil them. But what meaning have they for the working man? His ideas of "improved conditions" are particularly few. They may be summed up in the one desire—less work and more money. Greater leisure for the indulgence in what he believes gives him pleasure, and more money wherewith to encompass it—those are the ideals of most, and in their extreme form the leisure is complete, the money unlimited, and no one is to work. We need not seriously consider such dreams, except to notice them as indicative of his frame of mind. He does not advance his whole programme at the moment, neither does he allow the matter entirely to rest. Professing that the increase in his wages does not counterbalance the increase in prices he now comes forward with fresh demands, tending not so much to increased wages as to lesser production. Mistrusting the promises made to him during the war, he is losing no time in pressing his claims.

He is naturally deaf to all arguments based on economics, as he remembers that every application for an increase in wages was met by such. It has always been asserted that the industry must die if more wages were to be paid, and more have been paid and the industry has not always died, so now he smiles and says "the trade can stand it," referring the while to the dividends now being announced in respect of last year's trading. But he forgets that last year and this are different times. The large dividends paid during the war, when employers, with a patriotism not much better or worse than the men's, were plundering the State, cannot be repeated in ordinary trades for a long time to come.

It is now a question of existence, not of profits. You may tell the workman this, but you will not convince him. He has so often heard it that it now means nothing to him. He tells you that you are crying "Wolf," and so, indeed, you are, but the "wolf" is among the flock.

Furthermore, if by any chance you should convince one or two men by these arguments you are but little better off, for they have generally acquired the notion that the capitalist system itself must go before the masses can enjoy their dues; hence any injury to the capitalist is regarded as a gain to the worker. This notion is old, but still vigorous.

There are people concerned in industry who place some reliance on the better sense of the men's leaders. From my own acquaintance with leading trade unionists and from a study of their own press I am inclined to think that, while the intentions of the leaders may be excellent, their power to induce their members to an unpopular course of action is small.

The foregoing remarks may be summed up in one sentence. The men are from various causes determined upon a serious attempt to improve their worldly position and to that end are prepared to inflict very great damage to the industries of this country.

I have endeavoured to show that at the present time any disturbance of production, even a failure to reduce its cost, is likely to have disastrous results for this country, and have remarked that the workers are not disposed to credit any such reasoning. To a less extent, neither are the masters. The great majority are unhappily prone to consider this as just one more spasm of labour unrest, to be dealt with as previous ones have been. Confident in the advantage bestowed by the possession of capital many of them complacently observe that only a period of unemployment and distress will restore the spoilt workers to reason. We all know, and none knows it better than the workman does, the overpowering weapon capital has proved to be in the past, but so to regard it now is to take a dangerously narrow view of the crisis. The time is past when the plutocrat could isolate himself from the strife and live at his ease until hunger had subdued the recalcitrant masses. Kropotkin, in his interesting work, "The Conquest of Bread," shows that the revolutions of the past failed through the neglect to provide food for the people. Enthusiasts worked early and late in framing constitutions based on the great fallacies of Rousseau, in addressing their fellows and in being addressed, but the people starved. Then came the opportunity of the rich, and particularly of the rich countryman, possessed not only of money, but of food. The shibboleths of the Revolutionists were ridiculed. Liberty there was—to starve; fraternity—in distress; equality there was not, said the capitalists never would be. But, since Kropotkin wrote, there have been other revolutions, in which the matter of food has played a great part, but not the same one as of old. In Russia there has, we are told, been much starvation, but not of the masses. It has been the aristocracy that has starved. So is it now apparently in Austria and Hungary.

I do not cite these things with the intention of drawing any close parallel between those countries and ours. It would be irrational to do so. I cite them merely as a caution against the too common belief that any distress to come must press principally upon the working-class and so act upon the employer's side in bending them to his terms. I agree that in the first instance it will press upon the masses, but I strongly dissent from the belief that industrial unrest will again collapse for a time as a result of it. The working man of to-day is a being much different from him we knew five years ago. Ideas have been abroad for some time that have greatly altered his outlook. Some of the holiest tenets of the upper classes are no longer of any sanctity to him—even the sacred right of property is a law he accepts only with important qualifications, not with any covetous desire for naked appropriation, but from a reasoned scepticism, to which, of course, his poverty inclines him. The old security, too, in the power of law and good government would prove less reliable in a pinch now than formerly it proved. Most of these men have witnessed the recent appeal to primeval methods of dispute and much of the veneer of modern life has fallen from them or is ready to be discarded.

It is not, however, from any fear of the consequences to the middle and upper classes that I direct attention to these new ideas in the minds of the working men, but from a desire for all sakes to avoid a conflict the results of which are certain to be disastrous. Surely we are not so bankrupt of intelligence as to drift, through perversity, into such a catastrophe. England has never yet seen, because she has not needed, a popular revolution, yet the spread of selfishness in the land seems likely to produce one. The only preaching that is popular here to-day is the doctrine of Pleasure and, in a sociological view, there is no more dangerous poison. It is the natural outcome of the hysterical humanitarianism of Rousseau and is bringing, if it has not already brought, its own Nemesis. While Socialism affects to direct adoration to the State its appeal is always to the luxurious instincts of the individual, and there is no argument, nor any historical instance, to show that hedonism is a religion favourable to communistic progress.

But this side of the matter, disquieting though it is, is not the one I am now principally concerned with. The question we have to answer is, can this country avert a social disturbance likely to be fatal to it as a commercial nation? Judging solely from the present demeanour of each party to the dispute we would have reluctantly to confess that we must answer No. The average employer regards the position as unpromising because of its trade outlook and he is prepared for some recurrence of "labour" trouble of the kind he has known before and has vanquished by the power of the purse. He is usually ignorant of the lot of the working man and of his political beliefs and aims; he is quite ready to give the working man improved conditions if it can be done without affecting his own comfort, but he thinks the present time inopportune.

I desire, further, to say this of the average employer, that there are two things it is difficult to get him to realise: (1) That there are thousands of human beings in this country condemned all their lives to sordid labour and misery, and (2) such being proved, that it really matters. These are hard things to say, and I am careful to consider them before saying them.

A final word on the food question, which I consider to be the vital factor in the case. Our street-corner orator is fond of instancing in his own favour successful institutions in the Colonies which are to some extent steps on the road to Socialism. It cannot be too strongly emphasised that any country producing an excess of food can take some liberties in this direction; it is right and proper that experiments should be made, but it is dangerous to make them in a country that is indebted to outside sources for its food. In this matter the individual may stand for the nation. For the South Sea islander who can support himself from the bounties of Nature, total bankruptcy may mean inconvenience; for the British town dweller living on purchased food it would mean extinction.

It may be that this nation has run its course. Some think that it has, and that the march of world empire is about to take one more step westwards. I do not pretend to prophesy, but, believing that England stands for some great and noble things, I am loth to contemplate her extinction in chaos and misery.

There are one or two pertinent things yet to notice in our survey of the social position. The social reformers have never been able to deny, few have attempted it, that the first nation, amongst neighbours still following capitalism, to adopt the practices of Socialism is doomed to economic ruin. What that would mean to England no one can calmly picture.

A feature common to the times immediately preceding the great historical revolutions is the indifference and false security of the ruling classes on whom the worst horrors were later to fall. I fear that the same indifference pervades this country to-day.

Another thing to notice is the error of supposing that Socialism is a term connoting an ordered scheme of human policy. It is in reality a loose term covering an agglomeration of dissatisfied people who, for the moment, are following the same banner, whom the morrow of victory would find in the bitterest conflict. They are united in nothing but their enmity to capitalism. Once that system is down, or shaken, babel will ensue.

It is, of course, far easier to describe these symptoms of disease than to prescribe for their causes. Two things, however, it would be wise to do :—

1. Employers, if they desire the continuance of the present system, must make its inequalities less onerous, and in a spirit of genuine humanity not of intelligent selfishness, which concedes to the men only those things that serve to make them better instruments of production. And instead of ignoring the labour Press and propaganda, employers would do well to study them, to realise that some of the cleverest men in the country are behind the movement, and to take some trouble to put their own views before the workers.

2. The social reforms now so widely desired are either sense, half-sense, or nonsense. If they are sense they should not be resisted. With a Government ready for any expenditure on social business it should not be impossible to put these reforms to the test in some prescribed areas, say some convenient island. I make the suggestion seriously.

I am, yours truly,
CHARLES RUSSELL.

PULVERISED COAL IN THE OPEN-HEARTH FURNACE.

IN the course of a paper which he read before the American Society of Mechanical Engineers, at Detroit, last June, Mr. N. C. Harrison stated that all open-hearth furnaces using pulverised coal are of the reversing type. He believed there had been only one exception in the United States, that being the plant of the American Iron and Steel Manufacturing Co., Lebanon, Pa., where open-hearth furnaces were fired from one end only, the waste-heat boilers and economisers being installed on the other end. As an open-hearth proposition, this turned out to be a failure, but as a waste-heat-boiler proposition, it was a wonderful success. During 1918, the furnaces were remodelled and are now fired from both ends.

The pulverised coal is delivered into storage bins located at each end of the furnace. On the bottom of these bins are screw feeders driven by variable-speed motors for supplying the amount of coal desired. These carry the coal by gravity into the burner pipe. The burners usually carry a combination of compressed air at from 60 to 80 lbs. pressure, and fan air at about 8 oz. pressure. In some cases compressed air alone is used as the medium for conveying this coal into the furnace. The hearth of a pulverised coal open-hearth furnace is practically the same as the hearth of any other open-hearth furnace. The uptakes, slag pockets checker chambers are entirely different. The uptakes are made as small as possible so as to hold the gases in the furnace as long as possible without blowing, and the slag pockets are made as large as possible so that the gases will have a slow velocity going through them, thereby depositing a large percentage of the heavy particles that are in the outgoing gases. On account of this heavy deposit, removable slag pockets, or very deep stationary pockets, should be used, so as to collect the accumulation over the run of the furnace. Where removable slag pockets are used, they are taken out, cleaned and replaced about every two weeks. Only one checker chamber is needed on each end of the furnace. If the checker chamber is large enough, it should be built up with large tiles and laid in such a manner as to form vertical flues, having openings of at least 6 by 9 in., or better, 9 by 11 in. In some cases no checkers at all are used, but the chambers are fitted with baffle walls with openings from the outside, so that the accumulation between these baffle walls can be raked out. All passages from slag pockets to stack must be as straight as possible, and wherever any bends must be made some agitating device should be installed at these points. The reversing valves are usually of the mushroom and damper-slide type.

The best coal for use in pulverised form is bituminous coal as high in volatile matter as possible, and preferably low in ash. It should never contain less than 32 per cent. of volatile matter, or more than 8 per cent. of ash. It is necessary that the coal be as finely ground as possible; it should be so fine that about 97 per cent. will pass through the 100-mesh sieve, preferably 90 to 93 per cent. and not less than 85 per cent. through the 200-mesh sieve, and from 70 to 75 per cent. through the 300-mesh sieve. This very fine pulverisation is necessary for quick combustion and for the removal of sulphur in the coal. By this very fine pulverisation the attempt is made to have complete combustion before the flame strikes the bath, thereby burning out the sulphur in the coal to SO_2 gas which passes up the stack. In order to get complete combustion before striking the bath, this should be from 6 to 8 ft. from the end of the burners.

The paper contains tables on the cost of pulverising the coal.

THE "BLACKBURD" TORPEDO-CARRYING AEROPLANE.

CONSTRUCTED BY THE BLACKBURN AEROPLANE AND MOTOR COMPANY, LIMITED, ENGINEERS, LEEDS.

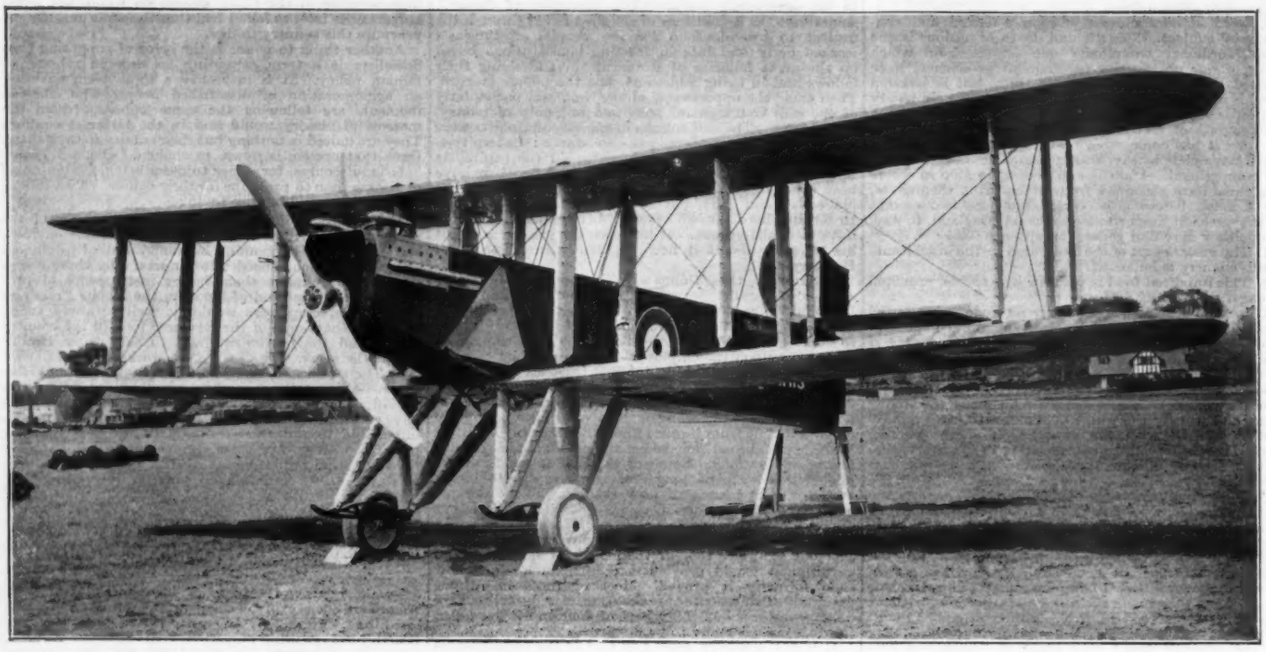


FIG. 1

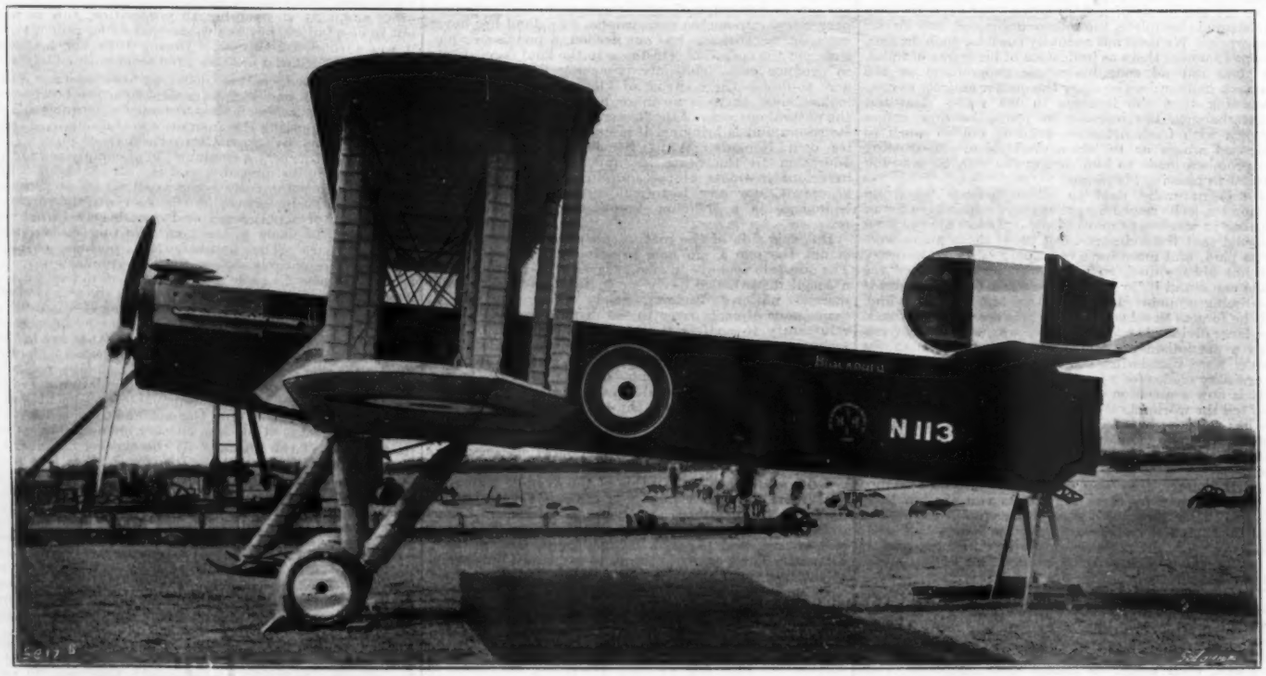


FIG. 2.

Now that the war is over, much is being said about the "mystery" aeroplanes which came into use just too late to prove their efficiency against the German Navy. Although torpedoes had been successfully carried and discharged from the air earlier in the war, they were by no means the efficient weapon which they would later on have proved themselves to be. The reason for this is not far to seek, as the requirements of an efficient torpedo-carrying aeroplane are difficult to meet. The Blackburn Aeroplane and Motor Company, Limited, Leeds, who have had ten years' experience of aircraft design and construction, are one of the pioneers of this type of machine, and towards the latter part of the war designed and built a machine called the "Blackburd," embodying some very ingenious and unique features of design, which illustrate the novel requirements of torpedo-carrying. The photographs reproduced in Figs. 1 and 2 show the first machine of this type.

Attached to our Fleet are several aeroplane-carrying ships which are capable of housing a score or so of aeroplanes, and it is to this branch of the Navy that the torpedo aeroplane is attached. It is thus in the category of ship aeroplanes, and for this reason must be small enough when folded to be stowable in the mother ship. On the other hand, it is required to carry a torpedo weighing well over half a ton, and this necessitates a machine of considerable weight-lifting capacity and power.

Another requirement of an aeroplane of this class is

THE "BLACKBURD" TORPEDO-CARRYING AEROPLANE.

CONSTRUCTED BY THE BLACKBURN AEROPLANE AND MOTOR COMPANY, LIMITED, ENGINEERS, LEEDS.

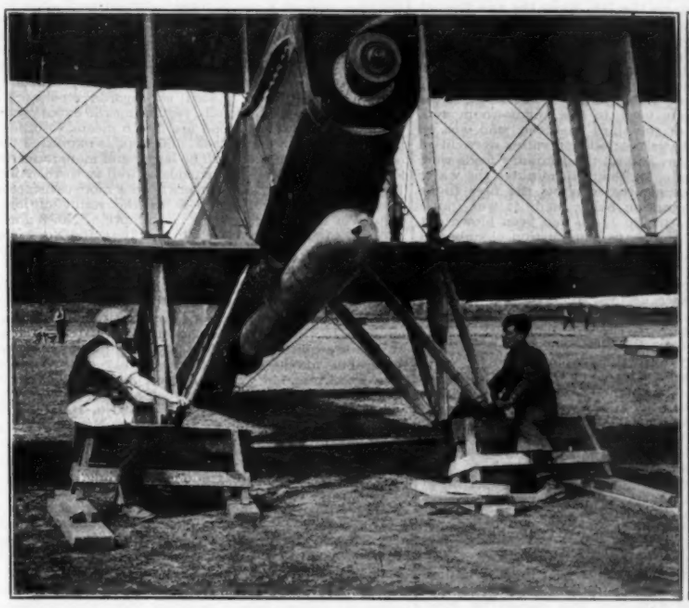


FIG. 3.

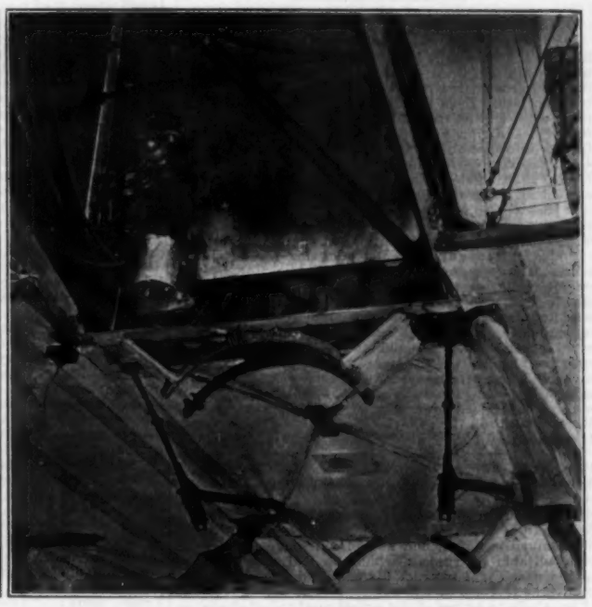


FIG. 4.

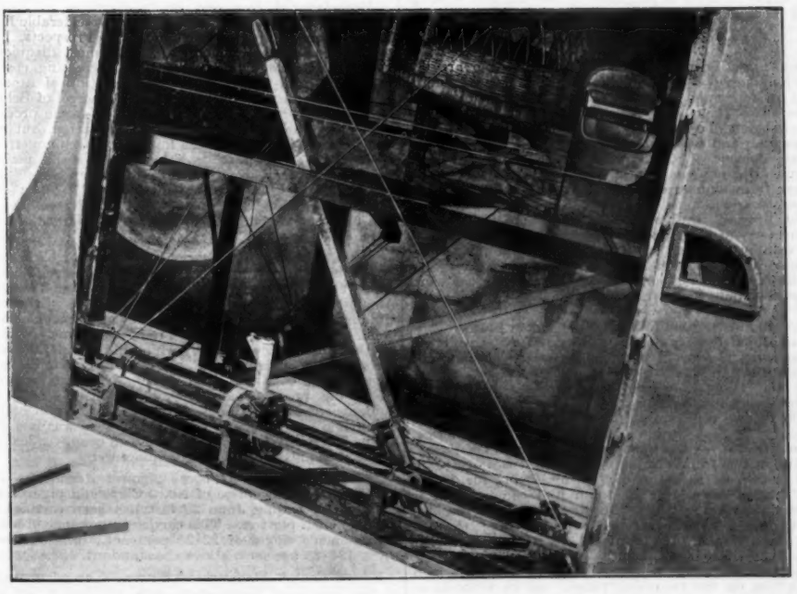


FIG. 5.

to rise from the deck of a ship, and as the run on a ship is necessarily very limited, the machine must be capable of getting off at a comparatively low speed, or, in other words, the lift component of the reaction on the wing section must be a maximum. In the "Blackburd" aeroplane this is obtained by the use of wing flaps, which are pulled down before flight, and consequently alter the wing section to one of deep camber and high maximum lifting capacity. When once off the deck the flaps are released and automatically resume their normal position. To prevent any instability, which might be caused by a too sudden change of section, a specially-constructed oil dashpot, shown in Fig. 5, is used, which allows the flaps to assume the neutral position gradually. In practice the time taken for this operation is about 43 seconds.

For getting off the deck wheels are fitted, but when once off, these, together with their axle, are dropped by means of a lever which also actuates the dashpot. By releasing the wheels, two long skeleton steel skids are left clear for use in case of landing again on the deck, and if it is inevitable that the machine should alight on the water, these skids have not the "tripping" effect that wheels possess. Once in the water, the machine is kept afloat by means of air bags fitted inside the fuselage and in the bottom of the engine cowl. Another interesting feature of this skid chassis is the arrangement of the springing gear. This consists of two vertical telescopic compression struts, which, when compressed, cause the skid to move slightly forward, with the result that when landing, the machine appears to creep forward, first on one skid and then on the other. Attached to the front tubes of the chassis are timber hydrovanes, one above the other, not shown in the illustrations, and the reaction of the water on these when alighting keeps the nose of the machine up and counteracts any tripping effect

There are several other special features in the design of this machine. The rectangular parallel fuselage is unusual and somewhat open to adverse criticism as regards appearance, but its lightness, ease of assembly, and the simplicity of the fittings easily outweigh this consideration. The ordinary top hamper, or fairing, is omitted, but the pilot is well shielded by being much lower in the fuselage than usual, in fact, the fuselage of this machine is equivalent to both the fuselage and fairing of a machine of ordinary design.

The torpedo is held in position as shown in Fig. 3 by means of two sets of crutches (see Fig. 4) and one adjustable tension strap round the torpedo itself. The hand petrol priming pump and the starting magneto are also shown on the left hand side of Fig. 4 inside the fuselage. These are, of course, used only when the machine is on the ground. In order to prevent the torpedo from moving fore and aft, a raised stop on the top of the torpedo fits into a fixed steel block on the under side of the fuselage. The control for dropping the torpedo is very ingenious, and at the same time fool proof. A long-handled wooden lever, shown in Fig. 5, is pulled into the rear position before flight and fixed there by means of spring plungers. Immediately after rising, the pilot pushes the lever forward and releases, by this one operation, both the wheels and axle, and the wing flaps previously mentioned. Now suppose the pilot wishes to drop the torpedo, he pulls back the lever into its original position and, by doing so, releases the two ends of the torpedo strap simultaneously, and starts the motor in the torpedo itself. When one considers that each control usually means a separate lever, and that the average torpedo-plane pilot has at least 15 different controls to operate, it is evidently a great boon to have four worked by one lever. Another advantage of this gear is that the torpedo cannot be released until the wheels and axle have been dropped clear.

The general construction and strength of the machine are of exceptionally high order, and many of the calculated strengths of the various parts have been checked by destruction tests in the testing department of the designing firm. The chief dimensions of the "Blackburd" are as follows:—

Span, spread, 52 ft. 6 in.; folded, 17 ft.
Gap, 7 ft.
Chord, 7 ft.
Height, folded, 14 ft.
Length, folded, 38 ft.
Wing section, R.A.F. 9 modified.
Weight with torpedo and full tanks, 5,800 lb.
Endurance, 5 hours, full power.
Load per brake-horse-power, 16.56 lb.
Load per square foot of wing, 8.18 lb.
Engine, 350-h.p. Rolls-Royce Eagle, water-cooled.

It is the intention of the Blackburn Aeroplane Company

to use this exceptionally good weight-carrying machine for commercial purposes, for which work it should prove very valuable either as a passenger-carrying machine, or, more especially, for express cargo and mail carrying.

DIESEL ENGINE USERS' ASSOCIATION.

At the meeting of the Diesel Engine Users' Association in June the President, Mr. Napier Prentice, reported that application had been made for a Government grant in connection with the carrying out of research work and tests on liquid fuels for Diesel and semi-Diesel engines, more especially on those fuels which are produced in this country, and that he hoped to be in a position to give further information on this matter at the next meeting.

The application of the Household Fuel and Lighting Order, 1918, to electricity supply undertakings using oil as fuel in place of coal was discussed. It was pointed out that the application of the Order to such undertakings at the present time was placing an unnecessary check on the output of electrical energy in the districts supplied by those undertakings, and that there could be no reason for consumers of electricity for lighting, heating or power purposes to be inconvenienced and harassed by restrictions in any area in which the supply of electricity was not derived from the burning of coal in furnaces under boilers. It was suggested that, on the contrary, every encouragement should be given to developing as speedily as possible the greatest use of electric power in such areas of supply. A resolution to that effect was unanimously passed, copies of which were to be sent to the Board of Trade, to the Controller of Coal Mines and to the Chief Electricity Commissioner Designate.

Mr. George E. Windeler read a short paper on "A Method of Checking the Alignment of Diesel Engine Shafts, and a Means of Proving if a Shaft is actually Bedding in its Bearings." He explained that he did not claim any novelty for his system, but that if other people knew of it previously they had apparently not made much use of it, and he claimed that with the use of a suitable instrument which he had designed any engine user could instruct his engine driver in making good practical use of the method. The end movement of the shaft, in excess of the actual mechanical clearance allowed, was an indication that springing of the crank-shaft was taking place for want of proper support, and that actually the shaft was being extended and contracted in length by the opening and closing of the gap between the crank-webs. A measure of this distortion was taken by measuring with a suitable instrument the distance between the crank-webs when the crank-pin was on the top centre and when it was on the bottom centre. A few thousandths of an inch difference in these two measurements indicated that the shaft was out of line. The method was especially valuable in regard to checking the alignment of outboard bearings. The instrument used was exhibited at the meeting. The method enabled a check to be taken at any time as to whether a shaft was properly supported or otherwise, without removing any parts. The method was also valuable when re-bedding a new bearing into position, as it enabled the refit to take place without removing other parts from the engine, and with a certainty that the whole of the bearings would be accurately in line.

BOILER EXPLOSION ON BOARD A STEAMSHIP.

THE Board of Trade have just issued a report of a preliminary inquiry as to a boiler explosion which occurred on February 7 last, on board the steamship Izaston when about 12 miles north of Yarmouth. The vessel was owned by Messrs. Edwards, Sons and Co., Bute-street, Cardiff. Fortunately, no person was either killed or injured by the explosion.

The report states that the boiler was of the marine cylindrical return-tube type, of steel, and was 15 ft. 3 in. diameter, by 10 ft. 3 in. long. There were three furnaces, each 3 ft. 6 in. diameter, of the ribbed type, with separate combustion chambers. The boiler was built to the scantlings required by Lloyd's rules, the thickness of the back and side plates being about ⅞ in., the plates being supported by screwed and nutted stays pitched about 7 in. apart. The boiler was fitted with the usual mountings, including two spring-loaded safety valves, loaded to a pressure of 160 lb. per square inch. It was made by Messrs. Blair and Co., Limited, of Stockton, in the year 1898, and was therefore about twenty years old. No repairs had been done to it since the vessel was taken over by the present owners, in January, 1918.

The boiler had been periodically inspected by the surveyors to "Lloyd's Register of Shipping." It was also inspected by the owner's superintending engineer in January, 1918, and by the chief engineer, Mr. W. Edmunds, on January 27, 1919; also at short intervals between these dates. The vessel, including the boilers, the report adds, was stated to have been insured with Lloyd's underwriters.

When the explosion took place a piece of the combustion chamber back plate close to one of the bottom stays of the centre furnace in the starboard boiler, was blown out, forming an opening through which the contents of the boiler escaped into the stokehold.

The explosion, the report states, appears to have been due to local corrosion on the fire side of the combustion chamber plate. The corrosion was probably caused by leakage from the adjacent stay, the plate having been reduced in thickness locally until it was unable to withstand the usual working pressure.

The following general remarks are made, in the report, by Mr. M. White, Surveyor to the Board of Trade at Dover:—

"The vessel is fitted with two main boilers working at a pressure of 160 lb. per square inch, with three furnaces in each boiler, which supply steam to a set of triple-expansion engines of 280 n.h.p. She left Blyth on February 6 last bound for Malta. All went well until about 2.45 p.m. on the 7th, when the two firemen on duty rushed into the engine-room and reported to the chief engineer, who was in the engine-room at the time, that water was coming from the port boiler. The chief engineer attempted to get into the stokehold, but found, owing to the quantity of hot water then on the firing platform, that he was unable to get to the front of the boiler. He then went back to the engine-room and, with the assistance of the third engineer, who was on watch, eased the safety valves; all stop valves were closed on the starboard boiler, and all the auxiliary feeds were put on the port boiler. In about 10 minutes the water had cleared away sufficiently to allow the fires to be drawn, and on examination being made it was found that a piece about 1¼ in. by 1¼ in. had been blown out of the back sheet of the centre combustion chamber in the vicinity of one of the bottom screwed stays, the plate having been reduced locally to under ½ in. in thickness. The master, on being informed that the vessel could only proceed under one boiler, decided to make for Yarmouth Roads, and anchored there about 3 p.m. Attempts were made by the engineers to effect a temporary repair, but owing to the proximity of the stay the repair did not prove satisfactory. On the advice of Lloyd's agent at Yarmouth the vessel left at 4.30 p.m. on the following day for Dover, and was berthed there on February 9. The repairs were put in hand, the defective part of the plate being cut out, and a riveted patch fitted under the supervision of Lloyd's surveyor, and the owner's superintendent.

The existence of the corrosion appears to have been known, and arrangements were made for repairs to be done while the vessel was at Blyth, but owing to labour troubles it was found that the repairs would be likely to entail undue delay of the ship, which was on Government charter, and it was decided to leave the repairs till her arrival in Malta."

In his "Observations" appended to the report Mr. Thomas Carlton, Engineer-in-Chief to the Board of Trade, adds: "This explosion was caused by local wasting of the back plate in the lower part of one of the combustion chambers. If, as stated in the report, the engineers knew of the wasting of the plate previously, they made an error of judgment in leaving port without some repair having been effected."

THE LATE LORD RAYLEIGH; ERRATA.—We are exceedingly sorry to have made an unfortunate misstatement in our memoir of the late Lord Rayleigh, on pages 19 to 21 of last week's issue. Lord Rayleigh was only married once, namely, to Evelyn, daughter of Mr. James Maitland Balfour and of Blanche daughter of the second Marquis of Salisbury, who survives him. Lady Blanche Balfour was not his second wife, as it would appear from our words on page 19. We have also to correct two overlooked misprints. There was a reference to the "virial" problem, not the "virtual" problem—as printed—of Clausius in the twenty-third line of the first column of page 20. About the middle of the third column of the same page it is said: The study of "radiative" phenomena he left to others; the word radiative should read "radioactive."

AERIAL PHOTOGRAPHIC MAPPING.—In our notice of the second Royal Society Soirée we mentioned, on page 845 of our issue of June 27 last, the aeroplane photographs of Palestine exhibited by Captain H. Hamshaw Thomas. They were taken from heights up to 14,000 ft., while in France some mapping has been done from heights of 20,000 ft., we understand. The development of aerial photography has been extraordinary. In America, automatic and semi-automatic cameras have been used, ranging in size from 4 in. by 5 in., with lenses of 8·5 in. focal length, up to plates of 8 in. by 10 in., for 50 in. focal length. The large Eastman K–1 camera used is entirely automatic; it is set on the floor of the fuselage and operated by a controlled wind turbine; the roll films admit of taking 100 pictures (8 in. by 10 in.) without reloading. One of the difficulties of the large films is their liability to vibrate; to overcome this the film is held by suction on the recording plane. At an altitude of 10,000 ft. this camera can, in a continuous trip, cover an area of 200 sq. miles, 2 sq. miles at a time.

THE SOUTH AND EAST AFRICAN YEAR BOOK AND GUIDE.—A copy of this publication for the current year, the twenty-fifth issue, has recently been received from the Union-Castle Mail Steamship Company, Limited, of 3 and 4, Fenchurch-street, London, E.C. 3. Although the contents of this guide have always given it something of the nature of a year book, this issue is the first in which that fact has been indicated in the title. The book is divided into sections of which the first is devoted to general information useful to travellers in South Africa. The next section describes routes for travellers, and also forms a gazetteer, while another section gives similar information with regard to East Africa. Information concerning game, sport and overland expeditions is given in a further section, and a large number of maps and diagrams are included to illustrate the matter in each division. The book is arranged throughout so that the various subjects dealt with fall in logical sequence, which not only simplifies matters for the ordinary reader, but also facilitates reference by those using the book as a gazetteer. The price of this edition is 2s. 6d., or post free 3s.

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

The Cleveland Iron Trade.—Owing to the anything but satisfactoy working of blast furnaces there is excessive output of the lower qualities of Cleveland pig-iron, and as a result forge, mottled and white iron are very plentiful. The comparatively low rates, however, at which these descriptions are freely offered fail to tempt buyers. Demand is almost entirely for foundry iron, which is much sought after on both home and foreign account, notwithstanding that many consumers are now fairly well placed as regards stocks. The authorities are still carefully regulating the export trade, but licences to ship abroad are by no means so difficult to obtain as they have been, and hope is expressed that in the near future there will be larger and more numerous loadings for despatch to neutrals as well as to the Allies. Distribution to home customers is on a more satisfactory scale, due to better facilities as the result of larger supply of trucks. For home consumption, No. 3 g.m.b. and No. 4 foundry are 160s., No. 1 is 164s. and No. 4 forge 157s. to 158s.; whilst export quotation are 5s. above these rates.

Hematite Iron.—There is not much East Coast hematite to be bought for early delivery. Makers were well sold over the next two months, and some of them do not care to commit themselves further to any extent. Home buyers are quite prepared to pay the limit price agreed upon, but purchasers for shipment abroad hesitate to give fixed maxima export figures, and as a matter of fact business has been put through at a little below such rates. Nos. 1, 2 and 3 are 200s. and No. 1 is 202s. 6d. for home use; and for export, mixed Nos. are put at 205s., and No. 1 at 207s. 6d.

Foreign Ore.—With a good many more steamers available for foreign ore, trade is expanding, and imports so far this month are about double what they were to the corresponding date in June, so that the situation is greatly improved. Quotations depend on rates at which ships can be chartered, and as the freight Bilbao-Middlesbrough is now 27s. 6d., best rubio should be in the vicinity of 56s. 6d. c.i.f. Tees.

Coke.—Value of coke shows rather marked upward tendency, though supply is rather more than sufficient to meet the heavy local requirements. Average blast-furnace quality is 39s. at the ovens, and low phosphorus sort 41s. 6d. at the ovens.

Manufactured Iron and Steel.—Business in finished iron and steel is quieter, but there are considerable home and foreign inquiries in the market. Prospects, however, are none too encouraging. The most disquieting features are the high and steadily increasing cost of production and the formidable competition of America and other countries. Recently a small parcel of Belgian bars was sold here at below the price of home product. Export quotations are matter for negotiation, but may be given at a little above the following which govern the home trade:—Common iron bars, 20l. 10s.; marked bars, 23l.; strip iron, 21l. 15s.; black sheets, 22l.; galvanised sheets, 27l. 10s.; ship rivets, 27l. 10s.; steel ship, bridge and tank plates, 17l. 15s.; steel angles, 17l. 5s.; steel joists, 17l.; and heavy sections of steel rails, 16l.

The Amalgamated Industrials, Limited, Scheme.—By acquiring the whole of the shares of Messrs. William Whitwell and Co., Limited, of Thornaby-on-Tees, the Amalgamated Industrials, Limited, take over the controlling interest in the Thornaby Ironworks, which include blast furnaces and iron bar-producing plant. This is another link in the scheme by which Industrials, Limited, are acquiring controlling interests in concerns in different parts of the country. The change of control will not affect the present management, which is under the guidance of Messrs. N. F. and J. F. Whitwell. Some little time ago a battery of 75 coke ovens was installed at the Thornaby Ironworks. The firm occupy a leading position as finished iron bar manufacturers.

Blast-furnacemen's Wages Again Advanced.—The average net selling price of No. 3 Cleveland pig-iron for the quarter ending June 30 last has been certified at 141s. 11·74d. per ton. This carries an advance in blast-furnacemen's wages of 22·25 per cent., bringing them up to 137·25 per cent. above the standard.

Record Consett Steelworkers' Wages.—The accountants to the Board of Conciliation and Arbitration for the Manufactured Iron and Steel Trade of the North of England have certified that the average net selling price of steel plates by the Consett Iron Company, Limited, to have been such as to raise the wages of steel millmen at Consett by 12½ per cent., bringing wages to 100 per cent. above the standard. When war broke out the wages at Consett stood at 12½ per cent. above the standard, and since then they have been increased—with special bonus—87½ per cent. The previous highest wages obtained at Consett was 27½ per cent. above the standard in the good times ending December, 1900.

WELSH COAL FOR STEAM WAGONS.—The National Council of the Commercial Motor Users' Association (Incorporated) has for some time been making representations to the Coal Controller in favour of the withdrawal of the present restrictions upon supplies of Welsh steam coal in many parts of the country. The council has now received notification from the Coal Controller that permits may be obtained by owners of steam wagons and tractors for the amount of Welsh steam coal required on making application in writing to Mr. Finlay Gibson, Secretary of the South Wales Coal and Coke Supply Committee, Cardiff.

NOTES FROM SOUTH YORKSHIRE.

SHEFFIELD, Wednesday.

Iron and Steel.—The sanguine view expressed in many quarters that the signing of peace would effect a marked improvement in the trade position is not borne out by facts. The rate of production is still far from satisfactory, and generally is reported to be anything between 30 per cent. and 50 per cent. below the pre-war standard. This is to some extent attributed to a slackness observable in the attitude of the workmen, due to a reaction after the strenuous efforts of the war, and it is hoped is a mere temporary phase. More serious is the fear that high prices of iron and steel in this country will act as a veritable barrier against expansion. Immediately after the signing of peace, steelmakers advanced their rates an average of 20*s.* per ton. Pig-iron has been steadily advancing for some time. Already American competition is a factor. Their prices have not advanced since the armistice, while Atlantic freights have dropped considerably. With no prospect of British steel becoming any cheaper in the near future, orders are already being placed in the States by local firms. During the past few weeks there has been an increased activity on the part of the rolling mills, but it has chiefly been on a multiplicity of small orders, and little forward buying is noticeable. Quotations generally vary according to conditions. Local acid Bessemer billets are marked at 17*l.* 17*s.* 6*d.*; acid Siemens, 18*l.* 2*s.* 6*d.*; basic, 16*l.* 10*s.* for soft acid, 16*l.* for hard qualities, all delivered. East Coast mixed hematites are 10*l.*, and West Coast 10*l.* 2*s.* 6*d.* Basic is making 18*l.* 12*s.* 6*d.*, foundry 8*l.* 2*s.* 6*d.* to 8*l.* 5*s.*, and forge 7*l.* 10*s.* to 8*l.* Iron and steel scrap are comparatively cheap, but an early rise is anticipated. Heavy orders are to hand for finished iron products, and the lighter trades are far from being able to cope with the flood of business which greater facilities for production would command.

South Yorkshire Coal Trade.—House coal continues in active request, the pressure on local collieries being greater than for some time past. Merchants report a considerable increase in the orders on their books, due largely to the increased facilities given to the public to lay in stocks. The supply is still inadequate to meet current requirements, and with the reduced working shift and low output there is little hope of an early improvement. Prices are unchanged, maximum rates being well held. So far as steam coal is concerned there continues a brisk demand both for inland use and export. Large steams are being increasingly taken by the railway companies, with their ever-advancing needs, while both steam nuts and slacks are short of the demand. Gas coal is going away freely, though the pressure is hardly so great as last month. Coke is selling well, blast furnace being quoted 42*s.* on rail at the ovens. Current quotations are as follows:—Best branch handpicked, 27*s.* to 28*s.*; Barnsley best Silkstone, 27*s.* to 27*s.* 6*d.*; Derbyshire best brights, 25*s.* to 26*s.*; Derbyshire house coal, 22*s.* 6*d.* to 23*s.* 6*d.*; best large nuts, 22*s.* 6*d.* to 23*s.* 6*d.*; small nuts, 21*s.* 6*d.* to 22*s.* 6*d.*; Yorkshire hards, 22*s.* 6*d* to 23*s.* 6*d.*; Derbyshire hards, 21*s.* 9*d.* to 22*s.* 9*d.*; best slacks, 18*s.* to 19*s.* 6*d.*; seconds, 16*s.* to 18*s.*; smalls, 13*s.* to 14*s.*

AGRICULTURAL TRACTORS IN THE UNITED STATES.—We read in *Commercial America* that record production of tractors in the United States in 1919 is estimated by manufacturers reporting to the office of Form Equipment Control, U.S. Department of Agriculture. The reports show a production of 132,597 tractors in 1918. The figure for 1919 is estimated to reach close upon 315,000. The number sold for export during 1918 was 36,351.

SOCIETY OF MOTOR MANUFACTURERS AND TRADERS.—At the annual general meeting of this society, held on the 3rd inst., it was announced that an agreement had been come to with the Society of British Aircraft Constructors and also that the negotiations with the Association of British Motor and Allied Manufacturers promised to produce a satisfactory agreement. Trials of farm tractors and implements had been fixed to be held at Lincoln in September next, and over 50 tractors had already been entered. It was also stated that arrangements were in progress for an exhibition of motor boats and marine and stationary engines to be held at Olympia in March, 1920, in connection with the British Gas and Oil Engine Manufacturers' Association and the Ship and Boat Builders' Association. Negotiations with the Scottish Motor Trades Association, it was mentioned, had resulted in the approval of their exhibition at Glasgow to be held in January next.

AMERICAN MERCHANT MARINE BILL.—A Bill is before the United States Senate, says *The Board of Trade Journal*, for the regulation of the sale or charter of American ships built during the war. Under it authority is given the President to invite tenders for chartering of cargo ships on "just and suitable" terms to enable such vessels to compete with foreign ships. Chartered vessels may be restricted to certain routes until these are fully developed, and special reference is made in this connection to the Pacific and South American traffic. With the exception of small steel craft, steel ships must be sold or chartered "only to citizens, firms or co-partnerships composed of citizens of the United States, or to corporations formed under the laws of the United States," and the capital stock of such concerns must at all times be owned and controlled by citizens of the United States up to 60 per cent. of the total. Without the written approval of the President there shall be no transfers of charters or of ownership.

NOTES FROM THE NORTH.

GLASGOW, Wednesday.

Scotch Steel Trade.—In the Scotch steel trade there is evidence of some slight increase in the pressure for delivery of various kinds of material. This is chiefly owing to the approach of the annual fair holidays, which commence next Thursday and last for at least ten days, during which time certain necessary repairs will be undertaken. Plate mills have been kept running so steadily for some time that in several establishments a good overhaul is contemplated while the works are closed down. The demand for ship plates is as strong as ever and shows no falling-off, indeed, the conditions are really abnormal. The bulk of the output is still almost, if not wholly, going into home consumption and is being used up as rapidly as it is delivered. Order books are well filled and inquiries for large quantities both for home and export are general. There is little going through on the latter account, however, as so much is required locally. The result is that American producers are supplying most of the foreign markets and are also offering fair quantities of various kinds of material for delivery here, and at prices which are a bit under those quoted by home makers. The position with regard to sectional material has not changed, and very little demand exists. The policy both of buyers and sellers is of a hand-to-mouth character owing to the existing state of things. Steady running is general in the steel sheet mills and a large tonnage is being put out, but the demand is not so pressing as it was, although order books are fairly well filled. Prices all round are unchanged, and there is no visible sign of these weakening, and so long as the present high level is maintained there seems little possibility of any extension of the export trade. An increase in tonnage within the next few months may have the effect of causing a reduction in freights, but although this would mean an increase in the general export trade of the country, unless the home demand for steel material should fall off considerably there would still be little available for shipment.

Malleable-Iron Trade.—There is no change to report in connection with the malleable iron trade of the West of Scotland, and the reduced output is quickly absorbed by consumers. Very little is being exported on account of the large home requirements, but inquiries are very fair and it is disappointing that a number of these cannot be accepted especially when the works could turn out a larger tonnage than at present. Meantime the bookings ensure steady employment for some time to come, and prices remain firm.

Scotch Pig-Iron Trade.—The position of the Scotch pig-iron trade still continues very strong, and every ton available is eagerly seized by buyers who cannot get sufficient to supply their needs. The present conditions are really exceptional as the extraordinary high price of iron seems to have little effect upon the demand. The rate of freight on raw ore to the Clyde is a trifle easier, but this has not weakened the pig-iron prices, which are still firm and have even an upward tendency. Steady deliveries of hematite are being made to the steel works, and a large demand exists for foundry iron, the price of *No.* 1 being round 10*l.* per ton. The total shipment of pig-iron from Glasgow Harbour last week amounted to 153 tons, all going foreign, against a total of 12 tons, coastwise, for the corresponding week of last year.

Scotch Coal Trade.—The Scotch coal trade is a shade quieter at the moment, but the pre-holiday rush at many establishments has absorbed a large lot of the available supply. There is little demand for dross. The export trade shows signs of improvement, and some fairly good shipments have lately gone through.

IMPROVEMENT OF CHRISTIANIA HARBOUR.—In view of the great traffic expected after the conclusion of peace the port authorities of Christiania have decided to make various improvements and extensions of the sheds and crane accommodation of the quays, says *The Anglo-Norwegian Trade Journal*. A sum of 615,000 kroner has been voted for the purpose.

MERCHANT VENTURERS' SECONDARY SCHOOL.—This school, which has been conducted for many years as a part of their Technical College by the Society of Merchant Venturers, an ancient Bristol Guild, will, at the end of the present term, be transferred to the Bristol Education Committee, and will become a municipal school. The Merchant Venturers conduct in their college the Faculty of Engineering of the University of Bristol, and the urgent need for additional space for this rapidly-growing Faculty has made it impossible for them to continue to house the secondary school, which, during the present session has provided for more than 400 boys, and would have numbered over 600 had it been possible to accept all the applicants for admission.

REPORTS OF THE ADVISORY COMMITTEE FOR AERONAUTICS.—We are informed that many of these reports, which were regarded as confidential during the war and only circulated privately, are now available for the public. The reports deal with such subjects as airship resistance, airship sheds, stability of airships and aeroplanes, propeller experiments, performances of aeroplanes, seaplane floats, flying-boat hulls, strength of struts, meteorological experiments, electric ignition and many other matters of interest to makers and users of aircraft, as well as to students of aerodynamics. They are mostly records of the work of the staff of the National Physical Laboratory and the Royal Aircraft Establishment, and are sold separately, at prices ranging from 1*s.* 6*d.* to 1*d.*, by H.M. Stationery Office. We understand that a list of those available can be obtained from H.M. Stationery Office, Imperial House, Kingsway, London, W.C. 2.

NOTES FROM THE SOUTH-WEST.

CARDIFF, Wednesday.

The Local Markets.—It is with great difficulty that the coal export trade of South Wales is being carried on. Loading operations are materially hampered owing to the difficulties experienced in shifting ships about in the docks. This work is now being carried out by ship's crews, but even so much delay is being caused. Owing to a shortage of transport facilities caused by detention in loading, collieries have been rendered idle and arrangements generally are upset. For spot loading, buyers are able to secure coals at prices materially below those asked for shipment even a week off. In fact, some sellers are willing to accept the minimum schedules in order to secure a quick clearance of wagons. For loading even a week off sellers, however, firmly demand from 15*s.* to 20*s.* over the schedule which makes best large coals from 55*s.* to 60*s.* for allied countries. This attitude is to a large extent adopted because of the reduction in the miners' working hours from eight to seven from July 16, and the almost certain prospects of reduced outputs to say nothing of the restriction that will be necessary in exports to conserve supplies for inland requirements.

Newport.—There is a strong demand for Monmouthshire coals, and for shipment ahead sellers are asking round 55*s.* to 57*s.* 6*d.* for Black Vein, Western Valley and Eastern Valley large nuts, and from 37*s.* 6*d.* to 45*s.* for smalls for shipment to allied countries. For immediate delivery many buyers, however, are ready to discount these prices to the extent of 10*s.* in order to secure empty wagons owing to the strike of riggers, &c., at Cardiff and Barry having upset loading arrangements and caused a congestion of traffic on the railways.

The Riggers' Strike.—Serious efforts have been made during the week to bring to a close the strike of riggers, boatmen and dock pilots at the Barry Docks for an increase of 20 per cent. in their total weekly earnings, but without success. In fact, the trouble has spread to Cardiff. At a meeting this afternoon, however, the riggers, &c., decided to resume work immediately pending the consideration of their claims by the Conciliation Board.

Coal Exports Control.—Mr. J. Reginald Lewis, formerly secretary of the Bristol Channel Shipping and Coal Co-ordinating Committee, which has now been dissolved, has been appointed by the Controller of Coal Mines to superintend, in conjunction with the District Coal and Coke Supplies Committee for South Wales and Monmouthshire, the supply of coal for shipment at ports in South Wales and Monmouthshire.

South Wales and Oil.—It is reported that bore holes are to be sunk in South Wales with a view to a search for petroleum. Traces of petroleum are stated to have been found in the Principality and American experts are sanguine of success, though this view is not shared by British geologists.

Rise in Steel-workers' Wages.—The audit for the three months ended March 31, presented to the quarterly meeting of the South Wales and Monmouthshire Iron and Steel-Workers' Sliding Scale Conciliation Board, yielded to the men an increase in the scale of 15½ per cent. This brings the scale up to 121½ per cent. above the standard for men not in receipt of the 1*s.* 3*d.* or 1*s.* per day bonus, in which case the scale will be 106½ per cent. above the standard.

SHIPBUILDING IN THE UNITED STATES.—The demand for American-built vessels is increasing, says *The Iron Trade Review*, Cleveland. Inquiries are reaching shipbuilders from private companies in America as well as from Europe. The Shipping Board is selling vessels more freely than anticipated, announcing on June 16 total sales up to that time of 332,045 deadweight tons of shipping for $51,856,620. In two days in the middle of June last, seven eastern ship operators purchased 19 steel vessels at from $210 to $225 per deadweight ton. The vessels range from 5,300 to 9,600 tons. One company bought six freighters. Of the 19 ships referred to, 12 are fabricated boats built by the Submarine Boat Corporation and at Hog Island.

DANGER FROM FUMIGATING GASES.—The following notice to shipowners and shipmasters has been issued by the Marine Department of the Board of Trade: "The attention of the Board of Trade has been called to several cases which have recently occurred in which members of the crews of vessels have lost their lives through inhaling the fumes of poisonous gases used in fumigating the holds of ships. The Board understand that in United States ports the gas most frequently used for this purpose is hydrocyanic acid gas. It is the practice of the United States authorities to take special precautions to aerate the holds of vessels by means of ventilating fans in order to prevent accidents, and they have also, it is understood, issued stringent rules requiring that after fumigation the Public Health Officer on duty must himself inspect the holds before any of the crew are allowed to enter them. Masters and owners of ships are warned of the serious danger to life which may arise through allowing persons to enter holds or other places, in which this or any other poisonous gas may have been used for fumigation, before the fumes have been completely dispersed. In United States ports they should see that the rules mentioned above are complied with before any of the crew are allowed to enter the holds. As an additional precaution it should be the practice to keep the hatches off and to let down wind sails for some time in order to circulate the air and thoroughly disperse the gases."

COAL-HANDLING PLANT AT NOBEL'S EXPLOSIVE FACTORY AT PEMBREY.

CONSTRUCTED BY MESSRS. STRACHAN AND HENSHAW, LIMITED, ENGINEERS, BRISTOL.

(*For Description, see Page* 38.)

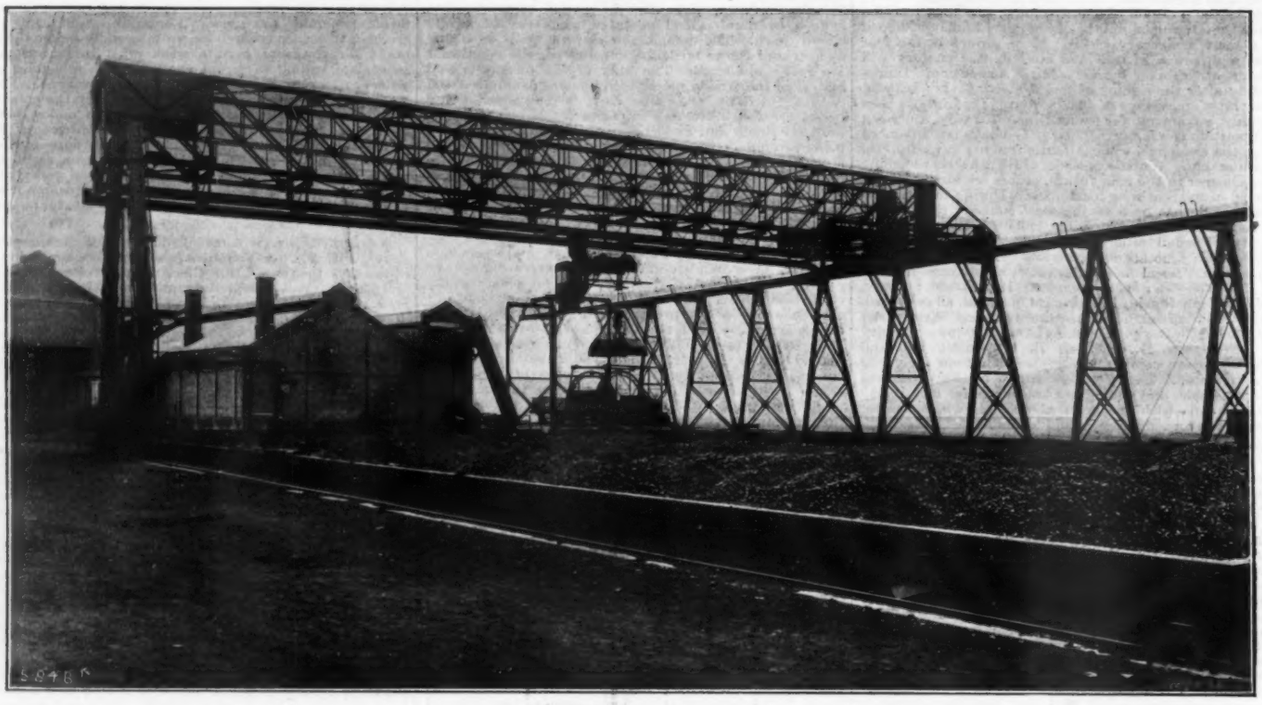


FIG. 1.

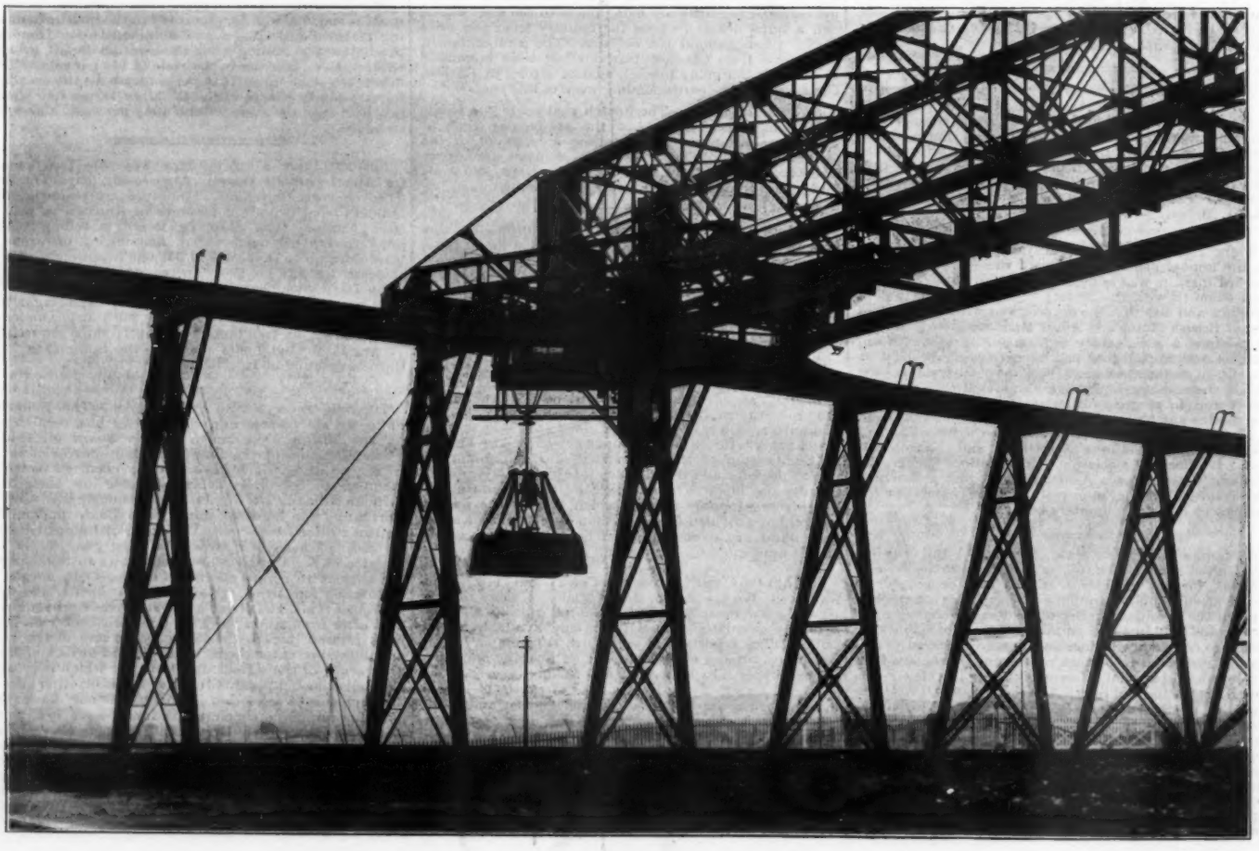


FIG. 2.

COAL-HANDLING PLANT AT NOBEL'S EXPLOSIVE FACTORY AT PEMBREY.

CONSTRUCTED BY MESSRS. STRACHAN AND HENSHAW, LIMITED, ENGINEERS, BRISTOL.

(For Description, see Page 38.)

Fig.3.

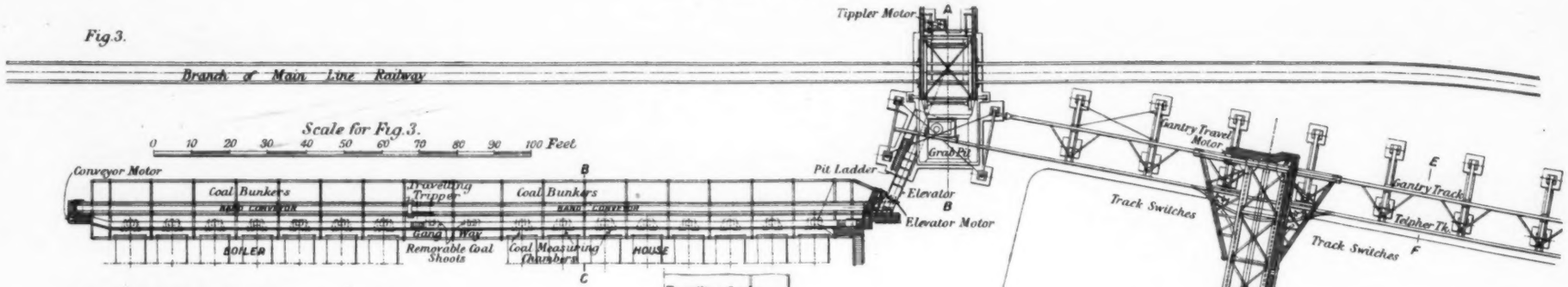


Fig.4. SECTIONAL VIEW ON AB-BC.

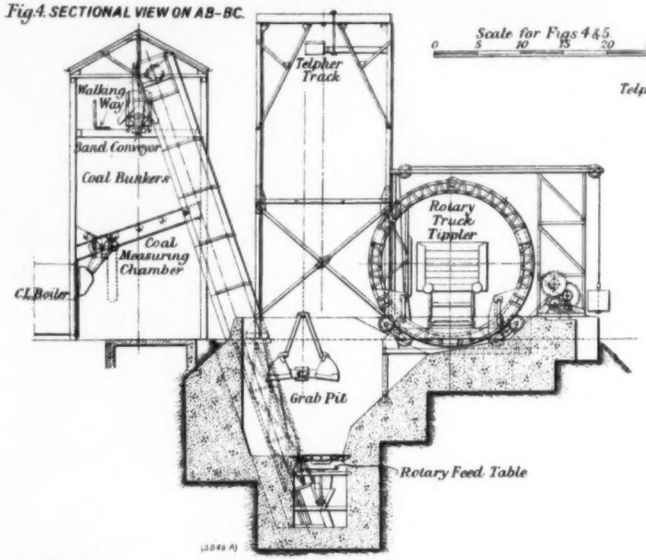


Fig.5.

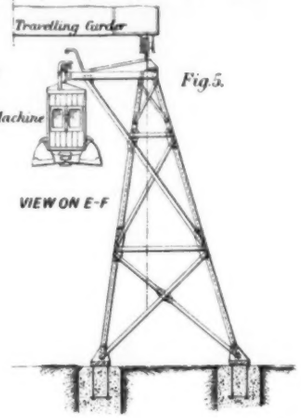


Fig.6.

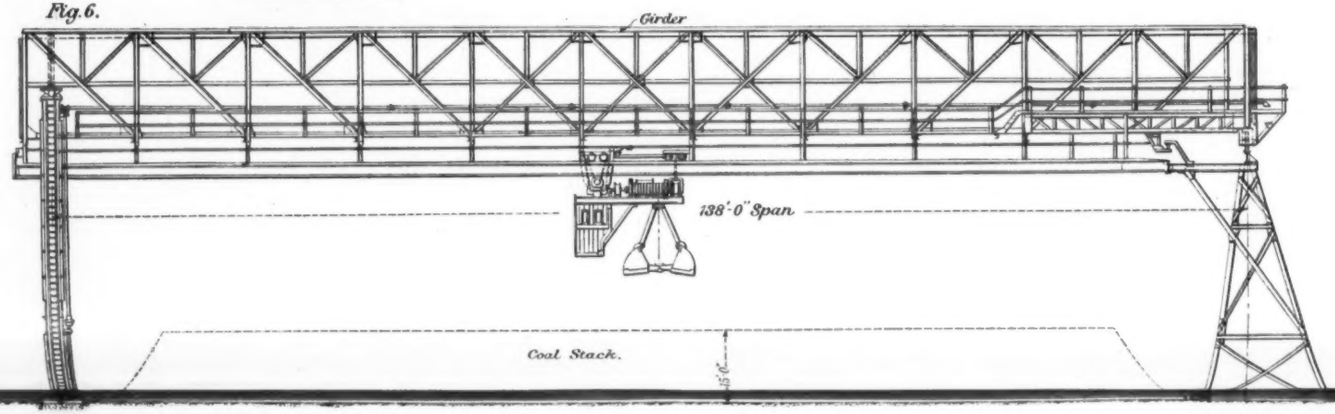
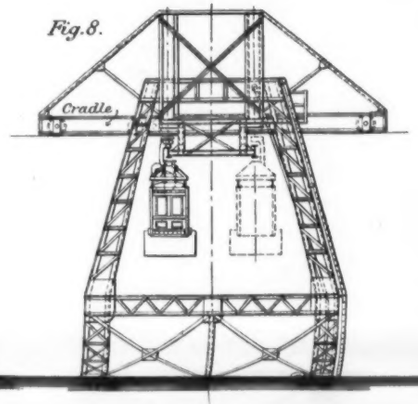


Fig.8.



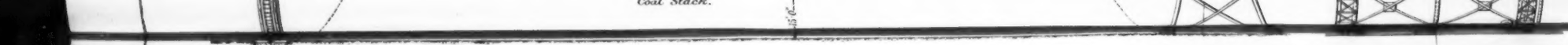
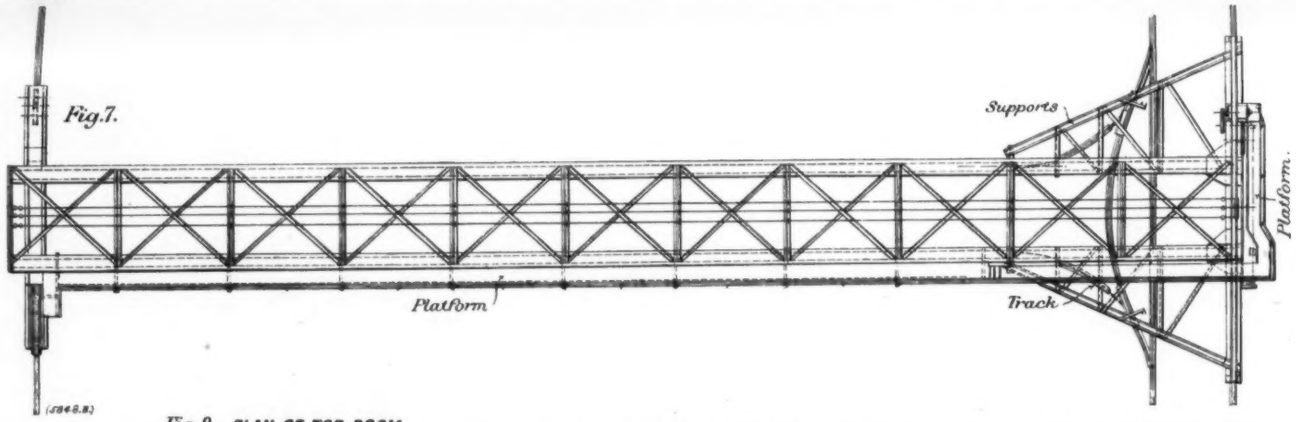
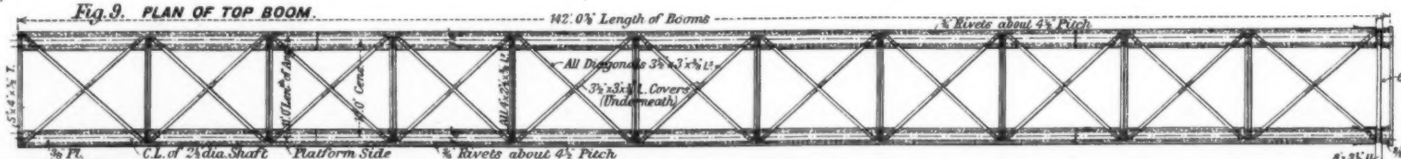


Fig.7.



(7848.B.)

Fig.9. PLAN OF TOP BOOM.



JOINT IN LOWER TOP FLANGE PLATE

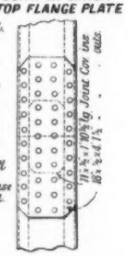


Fig.10.

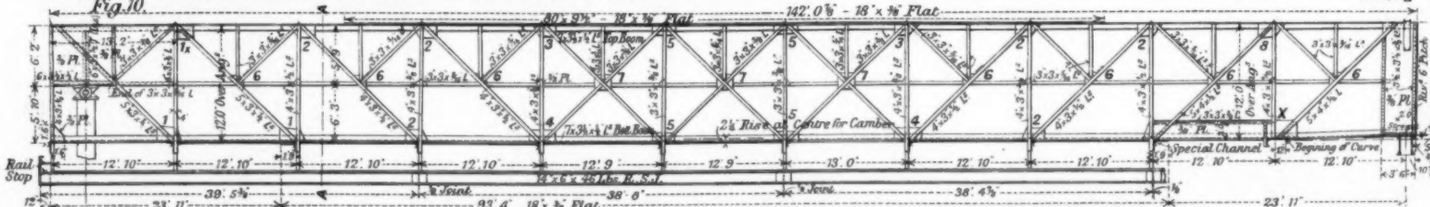
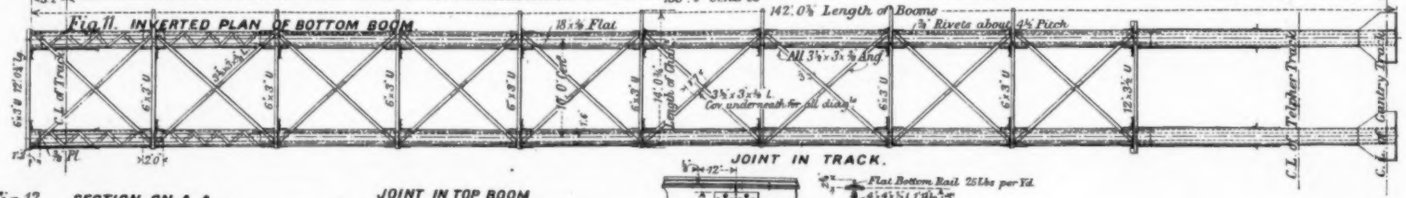


Fig.11. INVERTED PLAN OF BOTTOM BOOM.


18"x⅜" Flat
142'.0⅞" Length of Booms
⅞ Rivets about 4½" Pitch.
All 3½"x3"x⅜" Ang.
3½"x3½"x⅜" L. Cov. underneath for all diag.
C.L. of Track
C.L. of Telpher Track
C.L. of Gantry Track

JOINT IN TRACK.

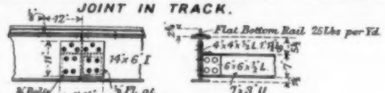
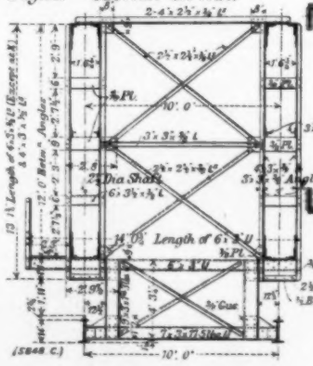
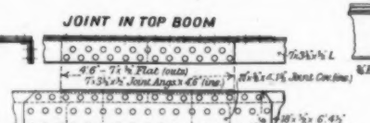


Fig.12. SECTION ON A.A.



JOINT IN TOP BOOM



JOINT IN BOTTOM BOOM.

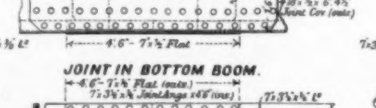
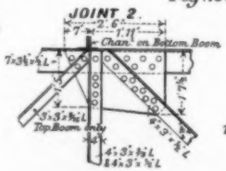
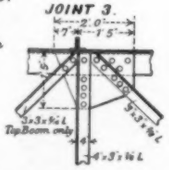


Fig.13.

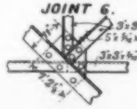
JOINT 2.



JOINT 3.



JOINT 6.



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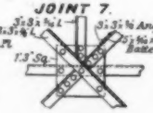

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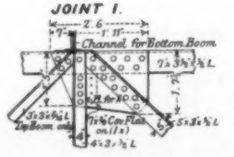

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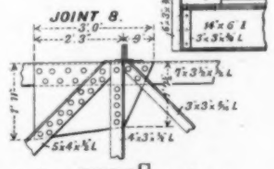

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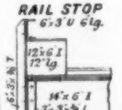

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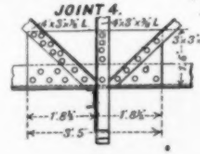

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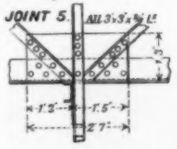

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NOTICE TO NON-SUBSCRIBERS.

In view of the restrictions now imposed by the Government on the importation of paper and the consequent shortage of Supplies, Newsagents will not have copies for chance customers: therefore readers who wish to be sure of obtaining "ENGINEERING" each week should place an order for the Journal with a newsagent or bookstall clerk.

ENGINEERING.

FRIDAY, JULY 11, 1919.

THE HIGH COMPRESSION OIL ENGINE.

SUFFICIENT prominence is seldom given to the part played by British engineers in the development of the oil engine. Propaganda and advertisement have been lavishly applied to the various types of engines built on the Continent, and these, together with our characteristic of self-depreciation, have been in part responsible. Undoubtedly economic conditions abroad conduced at an earlier date, and more strongly, to foster the advancement of this prime mover, and its development at home unquestionably lagged. It is, however, pleasing to be able now to record the opinion that in certain spheres British practice is coming rapidly to the front. Especially is this the case where considerable powers are concerned, and with such engines as the Semi-Diesel and the high compression or self-igniting oil engines, Britain, if not at present absolutely in the forefront, is taking a prominent place. Indeed we are pioneers and the first exponents of the so-called high compression oil engine.

Engines burning heavier oils than paraffin, can be divided into three broad classes, the Diesel, the high compression, and the Semi-Diesel. Definition of these types has often been attempted, but only with partial success. The Diesel and the Semi-Diesel engines are sufficiently well known not to require description. It is of the intermediate type, described as the high compression of self-igniting oil engine, that we now desire specifically to treat.

There has been in Britain a departure from the normal design of the Diesel engine, using, instead of the usual air injection system, a system of fuel injection using high pressure of fuel alone for injecting the liquid fuel into the combustion chamber in a sufficiently finely divided state for satisfactory combustion. With such a system lower compression pressures than are required with air injection engines suffice for satisfactory running. Two reasons can be given. Firstly, because of the relatively slow manner in which combustion starts with the "solid" supply system, fuel injection can be commenced many degrees before the dead centre, and this pre-injection gives heat to the gases and air within the combustion chamber to assist in the ignition and combustion of the ensuing charge of fuel. Secondly, because the cooling effect of the expanding fuel injection air is absent with solid or mechanical injection engines. This cooling effect with air injection engines must be counteracted by carrying the compression to a higher pressure and thus a higher temperature than otherwise would be required.

With Semi-Diesel or hot bulb engines, development has taken place along the lines of gradually increasing the compression pressure and reducing the area of the combustion chamber, which is left uncooled, to assist the compression pressure and to raise the consequent temperature to a figure requisite for the ignition of heavier oils. This latter movement has culminated in the production of an engine called the "high compression oil engine," which commences to function, as does the Diesel engine, without preheating of any part. This engine can be started from cold, with almost any oil of the petroleum series, and resembles the Semi-Diesel and the solid injection Diesel engine to the extent that no compressed air for the injection of the fuel is required.

There is yet another peculiarity. The great majority of Diesel engines, all in fact except a few examples of Continental origin which made their appearance a year or so prior to the war, are of the vertical type. The great majority of Semi-Diesel engines are vertical, and work on the two-stroke principle. All high compression oil engines have been, so far as is known, of the horizontal four-cycle type. There is little real basis for this demarcation. The first Diesel engine commercially successful was a vertical engine, the Semi-Diesel engine developed from the small vertical paraffin engine, and with the high compression engine, British horizontal gas engine practice has been followed.

If desirable, because of the conditions of the site, or the type of drive, either vertical or horizontal engines can equally well be built in the case of all these types. For instance, low head room favours the horizontal, marine work demands the vertical, and manufacturing costs where concentration on the smallest number of sizes of units is determined upon, and a range of power is obtained by multiplication of the units, gives advantages to the vertical type. Development towards making all these types either vertical or horizontal may confidently be expected.

The high compression oil engine has recently come into prominence, and reference may be made to the comprehensive tests carried out by Professor F. W. Burstall on a Crossley oil engine of this type. This engine, we may state, follows gas engine practice, and is a single cylinder horizontal engine rated at 117 b.h-p. at 180 r.p.m., the cylinder being 18·5 in. diameter, and 28 in. stroke. This gives a mean effective pressure at full load of some 68 lb. per square inch on a brake horse-power basis. This rating is, of course, a moderate one, as the engine will easily sustain an overload of 25 per cent. or more, yet, in comparison with four-cycle Diesel practice, this mean effective pressure is low. In other words, the engine is of large dimensions for the power output and speed of revolution, although the output per unit cylinder volume is greater than with the Semi-Diesel type. Within limits this fact is not of primary importance especially where low output per unit volume is not associated with a high fuel consumption as is certainly not the case with this engine. The figure of 68 lb. per square inch compares with some 80 lb. per square inch with the four-cycle Diesel engine.

With this high compression oil engine, the complication of the high pressure air compressor is eliminated, the compression-pressure as against the 450 lb. per square inch or even higher with the Diesel engine, is only some 200 lb. per square inch, with a maximum pressure of 340 lb. per square inch. Based on these pressures, the scantlings of the engine can be considerably reduced as compared with those required by Diesel practice. Not only is the maximum pressure of the cycle much lower, but it must be remembered that the maximum pressure that can be reached in an internal combustion engine cylinder is a multiple of the compression pressure, and this pressure must be legislated for when adopting factors of safety.

The tests were carried out with the maximum accuracy, and the results are of a high order, and cover a range of fuels from kerosene to tar oil. With tar oil a pilot injection of paraffin, as is frequently the case with Diesel engines, was employed. The consumption of this lighter oil at full load only reached 3 per cent. of the total consumption. The engine requires no preheating, but starts light, i.e., against no load, immediately with air under a pressure of 130 lb. per square inch. The fuel consumption, without any adjustment of timing of the fuel valve or of the means of injection was less than 0·5 lb. per brake horse-power per hour over the whole range of powers and fuels from half-load to a considerable overload, and was at full load with kerosene 0·427, with residual petroleum 0·425, and with tar oil 0·5 lb. per brake horse-power hour. This latter figure includes the consumption of lighter oil for ignition purposes. With modifications of the fuel injector and alteration in timing to suit the particular qualities of individual oil, it is stated that a consumption of 0·40 lb. per brake horse-power has been obtained with residual petroleum.

It will readily be admitted that these are very remarkable results. The diagrams taken with an optical indicator on these trials, confirm these results and show further that at loads less than

half load, and also when running light, ignition and combustion are certain and economical. Equally good results are not always obtained with Semi-Diesel engines, due to the large proportion of the injected oil which at light loads goes to keep the bulb at the requisite temperature for combustion, nor with the air injection Diesel engine, due to the waste of compressed air and its cooling effect on expansion, unless the devices for varying the pressure of the injection air and the timing of the fuel injection valve are very carefully adjusted.

ALCOHOL FOR POWER AND TRACTION PURPOSES.

THE report of the Inter-departmental Committee on the Production and Utilisation of Alcohol for Power and Traction Purposes, presented to Parliament on June 30, is of a rather disappointing generality. The problem has been discussed for years, and one expects a little more than the expression of opinion that the time has come for action by the Government to ensure close investigation of the questions of alcohol production and utilisation. One looks for definite information. But we willingly acknowledge that a good deal will have to be done to pave the way in administrative respects as well as in others, and it might not occur, for example, to the man in the omnibus that when the General Omnibus Company applied for permission to convey power alcohol by road in tank wagons, they were advised by the Board of Customs and Excise not to press their request.

The Committee was appointed in October, 1918, and the report is addressed to Mr. W. H. Long as Minister in charge of the Petroleum Executive. Sir Boverton Redwood, who died a few weeks ago, was chairman, and the chairmen of the two sections into which the Committee divided, were Sir Frederick L. Nathan (Production) and General Sir H. Capel Holden (Utilisation). The former section was to report on sources of alcohol and on the following matters: Waste lyes from sulphite-wood pulp; wood, including saw-dust and wood waste; peat; bracken and other vegetation; the mahua and other trees; potatoes, maize, molasses, &c.; seaweeds; synthesis; ferments, denaturants; residuals. We find hardly any particulars as to these sources, and chemists certainly do not appear to have been in the majority on the Committee; alcohol is after all a chemical product. So far as vegetable sources are concerned as raw material for the manufacture of alcohol, the Committee members consider that potatoes and artichokes (yielding 20 gals. of 95 per cent. alcohol per ton) cannot form a commercial source of alcohol in the United Kingdom, and that we should have to rely mainly if not entirely on production in tropical and sub-tropical countries. Such sources are sugar and molasses and the mahua trees of India; as to sulphite-cellulose nothing is said, and under the heading of future synthetic production we are referred to the extraction of ethylene from coal and coke-oven gases as a large potential source. There is no reference to the synthesis starting from acetylene which, by the aid of acid mercury salts as catalyst can be converted into aldehyde, and the aldehyde, by the further use of nickel as catalyst and of hydrogen, be transformed into alcohol. Several such processes were supposed to be worked in Germany during the war, and the Committee will probably know whether this is so or not. But the Swiss Government certainly granted a concession for such an alcohol process to the Lonza Elektrizitätswerk at Visp on the Rhône two years ago, the company agreeing to supply 2,500 tons of alcohol per year to the State. That production may yet hang back, but as the ethylene process is only a project so far, acetylene might have been mentioned as a source. The conversion of acetylene from calcium carbide would hardly pay in this kingdom; the case may be very different in the Dominions, however.

There is another omission which strikes us. Reference is made to the departmental committee on "Industrial Alcohol" of 1904, but not to the Imperial Motor Transport Conference which was held in Olympia in July, 1913,* and at which delegates from all parts of the Empire discussed the motor fuel problem, with special reference also to alcohol. People seemed to be very determined then, but probably nothing practical resulted. It is satisfactory, on the other hand, to read that mixtures of alcohol with benzol and with benzol-petrol are still being tried by the London General Omnibus Company on the suggestion of the Committee. There will clearly be a legal denaturation problem; but we agree that it should be possible to carry out the denaturing operations at transport depôts or yards under suitable relaxation of the Excise rules. Further, if alcohol be denatured to an approved specification before being landed in this country, it would appear superfluous to impose the usual bonded-warehouse rules and regulations for storage and handling. To avoid any misunderstanding the Committee proposes that the term "power alcohol" for alcohol be used for the purposes stated. All deliveries should be made, it is recommended, on the basis of a certified percentage by volume of absolute ethyl alcohol, with a minimum of 90 per cent. at a temperature of 62 deg. F., and in mixtures of alcohol with ether, petrol, benzol, &c., the volume ratio of water to alcohol should not exceed 1 : 9. That power alcohol can be mixed with water is one of its advantages. Some of the points we have mentioned were dealt with by the Utilisation section, which was also to report on primers, carburettors, designs and tests of alcohol engines, the marketing and distribution of alcohol, &c.; no information is given, however, on engines and their construction.

The final recommendation is that steps to facilitate the production and utilisation of power alcohol should be taken by the Government, but not unless provisions of the kind recommended be made in advance of the time when an acute recurrence of high prices for motor fuels might otherwise call for action too late for it to be effective.

* See ENGINEERING, July 25, 1913, page 124.

THE BRITISH SCIENTIFIC PRODUCTS EXHIBITION.

THE second British Scientific Products Exhibition was opened on Thursday, July 3, in the Central Hall, Westminster, by the Marquess of Crewe. Like the first exhibition, of last year, the Exhibition is entirely the work of the British Science Guild which has once more taken the initiative, has organised the Exhibition and has to shoulder the financial responsibility. The aims remain the same. The first exhibition was held when the war clouds were dispersing, but when the gigantic struggle was by no means over. All activities were turned in one direction, and the State still claimed the fullest possible output and bargained little. Times have changed. The new Exhibition is no longer a war display. The demand for many lines of goods has ceased; specialities which kept large factories busy are hardly wanted any more; reorganisation and reconstruction are proceeding everywhere, and the security against foreign competition is gone. On the other hand the manufacturer has learned that he can do a great deal that he had never attempted, and he sees his country in a position of unexampled strength.

Leaving apart the grave social and industrial unrest which overshadows all public questions, but with which the exhibition is not as such concerned, one may regard the problem of the actual position of British industries from the two main standpoints which were taken by the speakers of the opening meeting. The first exhibition had afforded an opportunity for vindicating the superiority of Great Britain in the field of discovery and invention. As Sir Richard Gregory, the chairman of the Organising Committee—whose untiring efforts all the speakers gratefully acknowledged—says in the introduction to the Catalogue:—"The ways in which we have met the demands forced upon us by the war has excited the wonder and admiration of the civilised world." There is as little doubt as to the capability of the British Empire to hold its own as there is as to the enormous resources of the Empire. When Lord Crewe said that the war had taught us that it was not wise to depend even upon our friends in all matters of manufacture, he did not mean to advocate Imperial exclusiveness, though he was careful not to commit himself to more than the remark that he would always prefer a real port from Portugal to other port wines. But other nations have learned their lessons as well, and competition will be fierce. Lord Moulton stated that all the nation had to fear was from its own self. The British manufacturers were too frequently content with a quality which they could sell in very large quantities and for which they had a safe market. Whether, however, British industry puts its trust into its own superiority, or take a despondent view of the future, it is clear that only the co-operation of scientific knowledge and methods and of industrial enterprise can hope to secure success in the coming times. That is the lesson which the British Science Guild wishes to bring home by arranging these exhibitions. There is danger that with the close of the war industry will drift back into its old grooves, not so much because of the indifference of manufacturers, as because of neglect of their interest by the State or a lack of encouragement of home products by the public, as Sir Richard Gregory puts it in the Foreword to the excellent Exhibition Catalogue from which we have already quoted.

The manufacturer has been much lectured of late, maligned, too, possibly. But when we read in the report of the Engineering Trades Committee that balances, barometers, drawing instruments, and physical apparatus generally, &c., had, before the war, largely been supplied by Germany, and had been sold here under the names of English dealers, and when we find that the chief thing some firms have to say about their products in the Catalogue is that the articles used to be practically a German monopoly, but that the firm is now supplying them superior to the German standard, certain strictures seem to be justified. The best means of overcoming any sluggish tendencies of the public generally, the industrials and the Government is by education. As to that, Lord Crewe pleaded for a sound general education, combined with and supplemented by some holiday training in works, on the American plan and by research work assisted by industrial scholarships.

The particular object of the second Exhibition of the Science Guild is to promote the development of the industries established under the stress of war, and to encourage the foundation of new British factories depending upon progressive science and invention. A great volume of fruitful scientific work has been carried out in the universities and research laboratories of the country during the war, but much of this work unfortunately remains under official seal. Some of it, however, may now be displayed, and it was a very happy idea of the Organising Committee to publish, in the section of the Catalogue dealing with the Nation's Debts to Science, accounts of the war investigations of the universities and other institutions, educational and industrial. These accounts, drawn up by the respective authorities, are alphabetically arranged as to locality and, though naturally of very unequal merit, they are on the whole decidedly instructive. The circular issued by the Department of Scientific and Industrial Research on the Government Scheme for Industrial Research is also reprinted. The British Research Associations already registered at the time the catalogue was printed were the associations for the Boot, Shoe and Allied Trades; for Cotton; Sugar; Motor and Allied Manufacturers; Photography; Portland Cement; Woollen and Worsted Industries; Scientific Instruments, while a large number of associations affecting rubber, iron and non-ferrous metals, shale oil, linen, aircraft, refractories, potteries, music, engineering and shipbuilding, baking, &c., were drafting articles of association or only waiting for registration. Sir Richard Gregory is further to be complimented upon his Lists of Scientific and Technical Books which, grouped under the headings Aeronautics, Agriculture, Biography and History of Science, Chemistry, Electrical Engineering, Engineering (with the sub-groups of Prime Movers and Mechanics), &c., down to Typography and Wireless Telegraphy, take up 60 pages of the Catalogue. Only recent books of recognised value have been included in the lists, and all the books mentioned can be obtained in the Exhibition at the bookstall of Messrs. A. and F. Denny, of 147, Strand, W.C. 2, whose

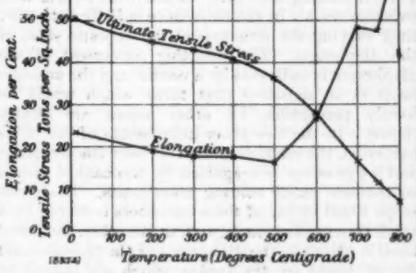
bookstall was much appreciated last year at King's College.

The rooms of King's College were not available this year, and the Exhibition is held in the Central Hall, Westminster, which implies that the Exhibition is rigorously closed on Sunday. It is to be open every week day from 11 a.m. to 7 p.m., except on Saturdays, when the hours are from 12 till 9 p.m. Like last year, the applications for space soon exceeded the space at disposal, and the ground floor and basement—badly ventilated unfortunately—of the Central Hall are in some parts simply crowded. Some well-known firms, latecomers possibly, could not secure more than the space necessary for one case, and inadvertently one may easily cross from one territory into another. The long corridors of King's College were not ideal for exhibition stands, but the large rooms afforded very convenient accommodation for certain groups. The grouping was a very much more difficult problem in the Central Hall. There was, moreover, the trouble that the Hall was vacated by its previous occupiers four days later than had been anticipated. As a consequence matters looked somewhat chaotic on the opening morning; but one has to acknowledge that by 3.30 in the afternoon—the opening ceremony in the big Hall upstairs began at 2.30—the Exhibition was quite presentable, and did not fail to attract the visitor. As President of the British Science Guild, Lord Sydenham presided over the opening meeting. The Guild bears all the burden, as we have stated. The Government support is limited to approval and to the participation of the Aeronautical Inspection Department.

The success of the King's College Exhibition, which was subsequently taken to Manchester, justified the repetition, and we hope that success will not be wanting. All the committee members are giving their services gratuitously. But the expenses are much higher than last year; no charge is made for space, nor for the descriptive notices—restricted as to space allowance—in the Catalogue, which this year is sold at 2*s.* 6*d.*; the admission fee is 1*s.*, and apart from donations these two items constitute the only sources of income on which the organisers can rely. It is also to be remembered that the aircraft exhibits which brought crowds to King's College have lost some of their attractive power, and as the show element is altogether wanting, the Exhibition will have to depend upon its intrinsic interest. There is certainly much to be learned. Firms which had exhibited on previous occasions have not failed to modify their displays, and a good many new firms have taken this opportunity of drawing attention to their novelties. A series of lectures on special aspects of the application of science was opened on Monday. Mr. F. S. Spiers, B.Sc., of 82, Victoria-street, is the organising secretary of the Exhibition. We begin our description of the exhibits with notes on those relating to aircraft.

Aircraft Section.—All exhibits in this section have been sent in by the Aeronautical Inspection Department, the director of which is Brigadier-General Bagnall-Wild, C.M.G., C.B.E. They certainly form a fairly representative collection of materials for aircraft construction, instruments, equipment, testing apparatus, &c., but would probably have been more complete if individual manufacturers had exhibited their own products. Doubtless more space would have been required, but the importance of the aeronautical industry fully warrants this.

In our view the most important feature of this section is the series of exhibits illustrating the application of metal construction to aeroplanes. As is now generally known, attention had to be given to this subject during the war, owing to the shortage of spruce—the most satisfactory timber for aircraft construction—arising from the abnormal demand. Apart from this, metal construction offers many advantages from the points of view of durability, reliability, fire resistance, lightness and resistance to atmospheric changes, so that its use is likely to develop considerably as aircraft come to be employed for commercial work—especially in tropical climates. Its chief drawback is, of course, increased cost, but doubtless improved manufacturing methods will considerably reduce this, and, in any case, durability is an important consideration in commercial work. Steel and Duralumin appear to be the only metals suitable for aircraft construction, and of the latter metal several wing spars, and a complete wing, made by Messrs. Vickers, Limited, are on view. One of the spars shown is suitable for the large four-engined Handley-Page bombing aeroplane, and it is made up of a strip of curved section and two angles, which together form one of the flanges. The two flanges are connected by lattice bracing formed of corrugated strips. Another Duralumin spar, designed for the "Vimy" bomber, is composed of two deeply corrugated flanges connected by lattice bracing of channel section. A complete wing made entirely of Duralumin, and suitable for an Avro 504 K. machine, is also shown. In this wing the spars are composed of curved section strips connected by two webs of shallow channel section, the webs being punched and lipped to form a sort of lattice structure. The ribs of this wing are also of Duralumin, and the leading edge and trailing edge are formed of cylindrical tubing and flattened tubing, respectively. Tested under static loading at the Royal Aircraft Establishment, at Farnborough, this wing supported, without failure, a load over



ten times the normal, the load being arranged to correspond with the centre of pressure in the extreme rear position.

Steel construction is represented by spars and complete wings, mostly composed of thin strips of high tensile steel and designed by several different firms. The Dunlop spar shown is suitable for an Avro wing, and is claimed to be 10 per cent. lighter and 30 per cent. stronger than the corresponding wooden spar. This spar is made up of three strips, one of curved section, forming the web, and two others, each of which is bent round to form a hollow flange and connected to the web by electric welding. Steel spars made by Messrs. Rudge-Whitworth, Limited, of Birmingham, The Aircraft Steel Construction Company, Limited, of Westminster, and Messrs. Boulton and Paul, Limited, of Norwich, are also shown. A complete wing made by the latter firm for use on an Avro machine is exhibited. In this wing the spars are of steel, but the ribs and leading edge are of wood. The trailing edge, however, is formed by a flattened steel tube. Under static test at Farnborough this wing withstood a load factor of 7 with the centre of pressure forward, and a load factor of 6·13 with the centre of pressure back. A similar wing of composite construction made by Messrs. Humber, Limited, of Coventry, also exhibited, withstood load factors of 7·27 and 5·08 with the centre of pressure forward and backward, respectively. Two other wings shown are made entirely of steel by the Steel Wing Company, Limited, of Pimlico. One of these, designed for the B.E. 2 D. machine, withstood a load factor of 5·82 with the centre of pressure forward, and the other, intended for the "Avro" machine, withstood load factors of 8·68 and 7·94 with the centre of pressure forward and backward, respectively. With regard to these wings, however, we are under the impression that the form of construction exhibited has been considerably modified and improved since the particular examples exhibited were made. Examples of steel struts made by the Birmingham Guild, Limited, and by Messrs. Sankey and Sons, Limited, of Hadley, Salop, are on view. One by the former firm is a very large strut suitable for the Handley-Page four-engined bombing machine, or for the Fairey N. 4 seaplane. Numerous samples of intricate steel tubework by Messrs. Accles and Pollock, Limited, of Oldbury, Birmingham, are also shown.

The only complete aeroplane engine shown is the Rolls-Royce "Eagle." This, as is now well known, is a 375-h.p., twelve-cylinder, water-cooled "Vee" type engine, running at 1,800 r.p.m. There are four carburettors, each connected to an inlet manifold supplying three cylinders, and the valves are placed on top of the cylinders. Parts of the engine, in various stages of manufacture, are exhibited, and these include the finished epicyclic gear, by which the speed of the propeller is reduced to 1,080 r.p.m. The construction of the 200-h.p. B.R. 2 engine is well illustrated by a collection of parts in the rough and finished states. This engine is of the nine-cylinder, rotary, air-cooled type, with aluminium cylinders and steel liners. The cylinders are shown in the form of rough castings, and also after machining. Other details shown in various stages are the aluminium pistons, master connecting rod, thrust box, nosepiece, cam-gear box and crankshaft. The cylinder head of this engine is a steel stamping, from which the radiating fins, valve seatings and guides are machined out of the solid. The whole process of machining is illustrated by examples taken at every stage, and these form a particularly interesting exhibit. This engine was made by Messrs. Gwynnes, of Hammersmith. Parts of the 80-h.p. and 110-h.p. Le Rhone engines, are also on view. A pair of cylinders of the R.A.F. 1 A. engine, cut through to show the construction, are included in the exhibit. This engine is of the air-cooled "Vee" type, having eight cylinders with an output of 90 h.p. at 1,600 r.p.m. to 1,800 r.p.m., but giving a maximum brake horse-power of 116. The example exhibited was made by the Lanchester Motor Company, Limited, of Birmingham. Three other engines are somewhat similarly represented, viz., the "Dragon Fly," "Cosmos" and Wolseley "Viper." Of the "Dragon Fly" engine, which is of the air-cooled type, and made by the Austin Motor Company, Limited, of Oxford-street, W., a single cylinder is shown in three stages of manufacture; first the rough machined forging after annealing; second with fins turned out of the solid and holes drilled and tapped for sparking plugs; and third with fins copper plated, and cylinder and valve seatings finished. Sectioned cylinders are shown of the "Cosmos" and Wolseley "Viper" engines, and, of the latter engine, the valves, and a pair of connecting rods, are shown in all stages of manufacture from rough forgings to finished articles. A section through the water and oil pumps of this engine is also included in the exhibit. The very extensive collection of materials, parts and accessories for aeroplane engines shown includes magnetos and parts, electric starters, steel stampings, aluminium die castings, sand castings in aluminium alloys, hot-brass pressings by Messrs. Elkington and Co., Limited, of Birmingham, and high-tensile bronzes by Messrs. J. Stone and Co., of Deptford. The casting of magneto spindles in a special bronze, by Haywood Foundries, Limited, of Seaton Street, N.W., is illustrated by an exhibit showing the castings in place in the lower half of the moulding box, from which the upper half has been removed. An interesting exhibit of this class is that showing the process of manufacturing tubes for aeroplane radiators by the Motor Radiator Manufacturing Company, of Birmingham. The tubes are drawn out to the required thinness from a fairly thick solid-drawn tube, and after cutting the thin tubes to length, the ends are expanded and pressed into hexagon shape. These tubes are fitted together and soldered at the hexagon parts, leaving spaces for the water between the cylindrical portions. Flattened tubes are used to fill the spaces round the periphery of a radiator. A large rectangular radiator, with rounded corners and a circular hole through the centre for the propeller shaft, is shown in connection with this exhibit. Before leaving the exhibits relating to aeroplane engines we should mention an interesting set of specimens shown of tungsten steel tested under tensile stress at high temperatures at the Royal Aircraft Establishment. This steel is used for valves which are, of course,

subjected to high temperatures under ordinary working conditions. The steel contains between 15 and 18 per cent. of tungsten and between 3 and 4 per cent. of chromium. The specimens are about 2 in. long, about 0·4 in. diameter at the screwed part, and about 0·2 in. diameter at the plain part. The figures obtained for ultimate tensile stress and elongation, measured on a length of 1 in., have been plotted in the diagram on the preceding page, which shows that the tensile strength decreases slowly up to about 500 deg. C., and then more rapidly, until it becomes almost negligible at 800 deg. C. The elongation also decreases at first, but increases very rapidly after a temperature of 500 deg. C. has been passed.

The wireless apparatus shown includes a complete installation for sending and receiving for use on aeroplanes or seaplanes. A 2½ kw. transmitter, with high-tension alternator, used on heavy seaplanes, is also on view, together with a number of small spark transmitters, airscrew-driven generators, continuous-wave transmitters, aircraft receivers, amplifiers, wavemeters, and wireless telephone apparatus. There is also a comparatively large continuous-wave set with a 1·6-h.p. motor and a 1 kw., 2,000-volt generator and switchboard, for use on ground stations.

Among the accessory apparatus of this class exhibited is a cartridge aerial for use on aircraft. This consists of a flexible copper wire coiled inside a lead weight, from which one end of the wire extends a short distance and then terminates in a lead button. The latter fits into a hook which slides in guides mounted on an ebonite baseplate, the hook being connected to a terminal by means of a spring. When it is required to use the wireless apparatus the lead weight is thrown overboard, and the flexible wire, which is thus pulled out, is left suspended from the hook. Connection to the terminal is effected through the spring, which also serves to absorb the shock. When finished with, the aerial can be detached from the hook and jettisoned, or recovered, according to circumstances.

Another interesting feature of the exhibit is the very complete collection of apparatus used for supplying oxygen for respiratory purposes at great altitudes. This includes light steel cylinders made by the Metallic Seamless Tube Company, Limited, of Birmingham, for containing gas at a pressure of 150 atmospheres. Two sizes are shown, one holding 300 litres and weighing 4½ lb., and the other holding 500 litres and weighing 7½ lb. The test pressure used is 3,750 lb. per square inch. The cylinders are connected to hand-controlled regulators, of which three types are exhibited. The first of these is an adaption of the ordinary commercial form of regulator, in which the delivery is practically independent of the cylinder pressure, but falls off at reduced atmospheric pressures and temperatures. Its weight is 4 lb. The second regulator, which was due to Lieutenant-Colonel Dreyer, R.A.F., is designed so that the delivery is unaffected by reduced atmospheric pressure. It is fitted with a flow indicator of the vane-wheel type, and weighs only 2½ lb. The third type of regulator is a development of the first, but the variations in delivery due to atmospheric pressure have been avoided. The design includes a flow meter, which consists of a button fitting loosely in a glass tube, the position of the button indicating the rate at which oxygen is being delivered to the pilot. The weight of this regulator is also 2½ lb. A bayonet union, which enables the pilot rapidly to connect himself to, or disconnect himself from, the oxygen supply, is shown, as also are masks which fit over the mouth and nose to enable the gas to be breathed. Liquid oxygen is also used for aviation purposes, and is stored for this purpose in vacuum-jacketted metal vessels of the type referred to on page 117 of our last volume. Several of these vessels are exhibited, as also are the vaporisers from which the gas is supplied, when required, by a system of heating coils arranged round the neck of the vessel. The complete outfit includes a control fitting for regulating the supply of gas, and a flow meter of the moving-vane type for indicating the rate at which the gas is being delivered. Bayonet unions and masks are used as mentioned above in connection with the high-pressure system.

A large number of aeronautical instruments are exhibited, such as air-speed indicators, altimeters, compasses, revolution counters, pressure gauges, and thermometers, many of which have luminous figures. Among them is a distant reading thermometer used for indicating the temperature of the water in the radiators of an aeroplane or airship. It depends for its action on the vapour pressure of ethyl ether contained in a small metal cylinder placed inside the radiator and connected, by metal tubing, to a pressure gauge of the Bourdon-tube type mounted in the cockpit. Other interesting instruments shown are turn indicators, which, by magnifying the yawing motion of an aeroplane, enable the course to be steered with much greater accuracy than would be possible by the use of the compass alone. Three types of turn indicators are shown. One of these depends for its action on the variation in pressure of the air in a long transverse tube fixed in the aeroplane structure, due to the centrifugal force set up in a turn. The outer ends of the tube are connected to swivelling static heads, so that the pressure at the ends of the tube is always equal to that of the external air and is not affected by the velocity of the machine. From the centre of the tube two branch pipes are led to the opposite sides of an extremely sensitive differential pressure gauge of the rubber-diaphragm type. It will be seen that a slight turning movement of the machine will tend to make the air in the tube move radially outwards, thus varying the pressure on the opposite sides of the diaphragm. The resulting movement of the diaphragm is indicated by a needle, and the arrangement is so sensitive that turns which would be hardly perceptible by other means are clearly shown. In the two other instruments of this class exhibited, the relative motion between the aeroplane and a gyroscope is magnified by mechanical means to indicate small turning movements. The gyroscope wheel in one of these indicators is driven by a small three-phase motor, and, in the other, the wheel itself is placed in the slip stream of the propeller and driven round by the spokes which are shaped to form a small air screw.

The Griffiths' gauge for indicating at a distance the level of petrol, or other liquids, in a tank, is also shown, but as we have recently illustrated and described this instrument (see page 846 of our last volume) we need make no further reference to it here. We may, however, briefly describe a number of instruments used more particularly in connection with airships, though many of them are also employed on aeroplanes. Such instruments include statoscopes for indicating the rate of ascent or descent of aircraft. In one instrument shown, made by the British Wright Company, Limited, of Chancery Lane, W.C., the reading is given by the movement of a drop of liquid along a curved tube, one end of which is connected to a thermos flask while the other is open to the air. When the machine descends the atmospheric pressure will become greater than that of the air in the flask, and cause the liquid to move inwards; an ascent will, of course, have the opposite effect. It should, however, be mentioned that the thermos flask is connected to the atmosphere through a very fine tube which allows the pressure in the flask to become equal to that of the atmosphere when the machine is flying at a constant altitude for any length of time. Another instrument for the same purpose, made by Messrs. Short and Mason, Limited, of Walthamstow, is a very sensitive form of aneroid, in which one scale division corresponds to a rise or fall of 6 ft. Several aeronautical navigating instruments are shown, including a liquid compass provided with a prism for observing, as used on the Sea Scout type of airships; the Bigsworth protractor and chart board, which enables the course and distance to be read off with the minimum number of instruments; and a bearing plate used for finding the bearing of an object relatively to the airship. The latter instrument can also be used for determining the direction of motion of the airship relatively to the earth. For detecting the leakage of hydrogen gas from airships, an instrument is shown in which the gas diffuses through a porous disc, forming one side of a closed box. Change of pressure inside the box due to the diffusion is indicated by a needle, and hence the presence of hydrogen in the atmosphere is shown. Two types of effusion meters, known respectively as the Kingsnorth and Alex. Wright patterns, are on view. These instruments are used for determining the degree of purity of airship gas. Other airship exhibits include cooking utensils heated by exhaust gases from the engines, control telephones used on the North Sea type of airships for communication between the pilot and the engineers, a number of different types of gas valves, and an auxiliary blower for inflating the ballonets of airships of the non-rigid type. For this purpose an airscoop placed in the slip stream of the propeller, as illustrated and described on page 759 of our last volume, is normally employed, and the auxiliary blower is only required when the main engines are not running, or are only running slowly. The auxiliary blower consists of a specially-designed airscrew mounted at the end of a converging tube connected to the ballonets, the airscrew being driven by a small two-cylinder petrol engine of the *vis-à-vis* type.

Among a large number of what may be described as miscellaneous exhibits, may be mentioned an instrument made by Messrs. W. and T. Avery, Limited, of Birmingham, for determining the tension in wires. This comprises a frame carrying two small pulleys over which the wire is passed. Midway between the pulleys, the wire is held by a screw clamp, to which one end of a lever pivoted on the frame is connected. To the other end of the lever a strong spring is attached, so that it tends to pull the clamp in a direction at right angles to the length of the wire. The deflection produced in this way in the wire, of course, depends upon its tension, and the resulting movement of the clamp and lever, which is indicated by a pointer connected to the lever by gearing, is a measure of the tension in the wire. The pointer moves over a scale graduated from 0 to 400, giving the tension in pounds. We also noticed an exhibit of good and defective timber for aircraft, and a collection of X-ray photographs showing defects in timber parts of aeroplanes; several of these photographs have already been reproduced in ENGINEERING, and will be found on page 611 of our last volume. The collection of cameras and lenses for aerial photography is interesting, but the demands upon our space are such that we can only mention them. The same remarks apply to the examples of good and defective doping, "Triplex" glass, models of "Airco" D.H. aeroplanes, a large model of a 4-ft. wind channel, and a complete water channel used in hydrodynamic experiments. We cannot, however, leave the exhibits in the Aircraft Section without referring to the collection of measuring appliances arranged by the Gauge Section of the Aeronautical Inspection Department. These include sets of Johannsen gauges and holders, a set of Newall standard test bars, a Newall measuring machine, a set of "Trojan" standard measuring discs, and a number of machines for measuring screw gauges. Two of the latter made by Messrs. Trojan, Limited, of Croydon, are of the type in which cylindrical needles, or "vee" blocks, are used, in conjunction with a micrometer, to measure effective and core diameters of screws. In another type of machine shown, designed by Mr. L. H. Hounsfield and also made by Messrs. Trojan, Limited, the screw gauge to be measured is placed between centres, and can be moved longitudinally by means of a micrometer screw with a disc head reading to 0·0001 in. A needle, which bears on the sloping side of the thread, is connected to a small glass prism so that it imparts a rocking motion to the latter when the screw is moved by the micrometer. Light from an electric lamp, mounted at one end of the baseplate of the machine, passes through a lens in a horizontal direction parallel with the screw, through the prism, up to a mirror fixed some 7 ft. or 8 ft. above the machine, and down again to a scale fixed on the bench, where an image of a cross wire is formed. In measuring a screw the needle is placed in position about half-way up the slope of a thread and the apparatus adjusted to bring the image of the wire on to the scale. After noting the reading of the scale and micrometer, the latter is turned until the image again occupies the same position on the scale after the needle has travelled over one thread. The difference in the micrometer reading then gives

the pitch of that particular thread. This operation can be continued over the whole length of the screw, and the results tabulated to determine the errors. A microscope, fitted with a protractor and vernier on the eyepiece, is provided for measuring the angles of the thread. A number of gauges, and other measuring appliances, used in the construction of aeroplane engines, are also exhibited at the same stand.

(To be continued.)

THE MOUNT WILSON OBSERVATORY.

THE disturbing influence of the war has made itself felt in the calm atmosphere of Mount Wilson, for Professor George E. Hale, the director of the Mount Wilson Observatory, reports that more than one-half of the entire time of the working staff has been devoted to the construction of instruments and experimental apparatus relating to war service. There has been a corresponding reduction in purely scientific activity, and much of the available time has necessarily been centred on the 100-in. telescope and its accessories. It is satisfactory to know that the great light-gathering power of the instrument will be used to full advantage under good observing conditions, as proved by the extraordinary amount of detail seen on the lunar surface. At the same time, star images show considerable flare, which appears to be due partly to temperature effects and partly to imperfect collimation, arising from lack of rigidity in the support of the convex mirror of the Cassegrain combination. Steps have been taken to remove the latter of these causes, by strengthening the support of the mirror by means of a compression ring inserted in the tube sections carrying the mirror. This arrangement has improved the image, and work is now being carried on to give complete temperature control to the 100-in. mirror, and effectually remove the first cause of defect. A most satisfactory feature in the mounting is the ample power of the driving clock and the ease and control of the entire instrument.

Another large piece of work that has been brought to a successful issue is the polishing and figuring of the Newtonian plane mirror for the huge reflector. The figuring of this mirror, of the ordinary oval form, with diameters 34 in. and 24 in., respectively, has occupied the whole time of one optician for some seven months. The oval coudé plane mirror, demanding a similar length of time, is not yet finished. The ruling machine for large optical gratings, of which mention has been made in these columns, is still under construction, so far as minute details are concerned. The ruby thrust bearing was finished at the end of 1917 and works admirably, but ruling tests showed the necessity of some minor adjustments. These have been made, and at the date of the report the machine was quite free from periodic errors. Many experimental 4-in. gratings have been ruled and most of these will prove useful optical instruments.

The increased number of instruments and the wider range of investigation now possible, have determined the authorities to alter the designation of the observatory. The word "solar" will in future be omitted. This alteration in name intimates no change of plan. The sun, as the only star that can be studied in detail must remain the central feature of observation, but an erroneous impression of the wide embracing purposes of the observatory might be created, if any restrictive term were employed to describe its functions. Henceforward, therefore, the Mount Wilson Observatory may be considered fully launched on the broad ocean of astronomical research. We offer our congratulations to the observatory staff on their declared entrance to a wider field of astronomical inquiry.

The success that has attended the investigation of the sun's surface, particularly in respect of the magnetic field and the determination of the inclination of the magnetic axis, is well known, and the director is able to report progress in several directions depending on the pursuit of the same class of research. A very earnest attempt has been made to improve instrumental methods and apparatus, so as to obtain the daily observation of those solar phenomena, only seen at times of total eclipse. Ever since the spectroscope made it possible to study the hydrogen prominences around the sun's disc in daylight, the hope of seeing or detecting the corona by an instrumental device has been the favourite dream of many astronomers. Up to the present, the sun has successfully eluded all attempts to penetrate this mystery, and Professor Hale's endeavour has been no more successful than that of others. We must still avail ourselves of the brief moments of a total solar eclipse to study the filmy details of the corona, and other faint phenomena near the sun's surface. After the very determined effort of Professor Hale and the observatory staff, success in this direction will to many seem hopeless, but the director's ingenuity and perhaps his perseverance are not yet exhausted. He concludes the account of his experiments with the remark: "It is perhaps barely possible to send meteorological balloons, carrying automatic photographic apparatus, directed toward the sun by a gyrostat, and finally controlled automatically by the heat of the sun's image, to a height sufficiently great to allow the corona to be photographed without an eclipse. But the technical difficulties would be considerable."

Passing to the region of the stars it may be mentioned that Nova Aquilæ, No. 3, has been repeatedly photographed, and the spectrum exhaustively studied. The large displacement of the lines towards the violet end of the spectrum, by amounts proportional to the wave-length, offers some difficulties of interpretation. If due to radial velocity the displacement would imply a motion approaching 1,500 km. per second in the illuminated mass. Velocities of this order can only be accepted with reserve, yet it is "most difficult to conceive of any physical cause other than motion of the source, which would produce displacements of this magnitude, proportional to wave-length and at the same time leave the lines comparatively narrow and well defined." The regions about the Andromeda Nebula and Nova Persei have been repeatedly photographed with the 60-in. reflector, the plates being exposed from 30 minutes to 330 minutes. The result has been to discover six additional Novæ in the nebula, bringing the entire number up to eight, and to give marked evidence of rotation of the nebula. This latter result was due to a spectogram that required 79 hours' exposure! At a distance of 150 seconds from the nucleus, opposite points in the nebula showed radial velocities which differed by 170 km. For intermediate points a corresponding relationship between velocity and distance was indicated. Photographs of Nova Persei revealed or confirmed the presence of a sharply-defined continuous ring of nebulosity about the star, 16 seconds in diameter. This ring can just be detected with a 10 minutes' exposure, and was discovered visually by Professor Barnard.

Inquiries into stellar parallax have been actively prosecuted. Besides stars possessing some peculiar interest, the working lists of objects have included sundry spiral and planetary nebulæ. The spiral nebulæ are very remote, but the planetary nebula is only about one-fourth that of the spiral. Barnard's star of large proper motion has a parallax of slightly over half a second, implying a distance of one-hundredth that of the spiral nebulæ.

The investigation of star clusters, globular systems, variable stars, &c., has led to what is considered to be a reliable method for determining the absolute distances of such objects. These distances greatly exceed those appearing in stellar studies, and the analysis of the spatial distribution of the clusters brings to light numerous interesting points that have some bearing on the problem of the structure of the universe. "In particular, it appears that the globular clusters are secondary organisations as compared with the whole galactic system, which in volume is at least 100,000 times that commonly accepted heretofore." The notion of "island universes" is apparently discredited, or at least grave objections are presented that make the acceptance of that hypothesis increasingly difficult.

NOTES.

CANADIAN INDUSTRIES.

WHEN the armistice was signed, on November 11, 1918, the activities displayed by Canada were almost at their peak, says Mr. F. W. Field, H.M. Trade Commissioner at Toronto, in his report on the trade of Canada and Newfoundland, for the year 1918. A number of new war contracts had then recently been obtained. Had the war continued a few weeks, the Dominion would have been engaged in what may be termed as its second great industrial effort, the filling of orders for the United States and, to a lesser extent, for the United Kingdom. The first great effort was the filling of United Kingdom and Canadian war orders. The result of this war work have been a great increase in the capacity and volume of production of Canadian factories, and a somewhat unexpected termination of war orders and subsequent efforts to turn the production of works into peace lines. The creation of the Canadian National Railways by the Dominion Government was the principal event in railway circles in 1918. This was accomplished through the acquisition, by arbitration, of all the capital stock of the Canadian Northern Railway Company, and later by the consolidation of that system's lines with the Intercolonial and Transcontinental Railways previously administered by the Minister of Railways. The combined system, now embraced under the collective title of Canadian National Railways, has been placed under one Board of Directors. Government ownership has thus been put into effect with a system serving every province of the Dominion, having a total mileage of about 14,000 miles, or about 35 per cent. of the total railway mileage of Canada. The average gross earnings per mile of line of the Canadian National Railways are about half the amount per mile earned by the Canadian Pacific Railway, being somewhat over 5,000 dols. per mile for the National system, as against over 10,000 dols. for the Canadian Pacific Railway. This position is ascribed by the president of the Canadian National Railways to the fact that certain of the territory served by some of the Government lines is partially developed. The production of all metals, with the exception of gold and silver, was greater in 1918 than in the previous year. In the case of nickel, zinc, pig-iron and cobalt, the production was larger than in any previous year. The production of pig-iron was 1,182,000 short tons, that of steel ingots and castings 1,910,000 short tons (including about 125,000 tons of electric steel), of copper 115,000,000 lb., of zinc 36,000,000 lb., of nickel 90,000,000 lb., whilst the coal output was 15,180,000 short tons. The Canadian Honorary Advisory Council for Scientific and Industrial Research continued its activities in 1918. In co-operation with the Manitoba and Saskatchewan Governments, a plant is to be put down in Southern Saskatchewan to test the commercial feasibility of carbonising and briquetting the Western Canadian lignites for heating in domestic furnaces. A revival of the Canadian shipbuilding industry occurred as a result of war activities. It is estimated that the total tonnage of vessels launched in Canadian shipbuilding yards during 1918 was about 460,000 tons deadweight. Of these, 23 steel and 45 wooden ships, for 253,463 tons deadweight, were for the Imperial Munitions Board. In the autumn of the year, the French Government contracted in Canada for 50 wooden ships. The Imperial Munitions Board awarded contracts for 46 wooden and 44 steel ships, having a deadweight tonnage of 356,343 tons. Another important development is the decision of the Canadian Government to establish a mercantile marine. The present plans call for the construction of 39 vessels. Of these, there are 2 of 10,500 tons, 14 of 8,100 tons, 8 of 5,100 tons, 6 of 4,300 tons, and 9 of the "Lake" type.

THE LATENT HEAT OF STEAM AND THE MECHANICAL EQUIVALENT OF HEAT.

In 1917 Mr. T. Carlton Sutton, of the University of Melbourne, presented to the London Royal Society (Proceedings, vol. xciii, pages 155 to 176) an account of his determinations of the "Heat of Vaporisation of Water at 100 deg. C. and 1 Atmosphere," measured directly in terms of the mean calorie with the aid of a modified Joly calorimeter. The principle of the method is the following:—The temperature of a bulb of capacity K is raised from freezing point ψ to boiling point θ by surrounding it with steam; a mass of steam m will be condensed on the bulb when $K(\psi - \theta) = m L$. The bulb is then filled with a mass M of water, and the

process is repeated, the mass of condensed steam being now m_1; hence $(K + M s)(\psi - \theta) = m_1 L$, and $L = Ms\ (\psi - \theta)\ (m_1 - m)$ *i.e.*, the heat of vaporisation is measurable in appropriate calories ($s = 1$) in terms of a temperature difference and of the ratio of the masses of water M and $(m_1 - m)$. In carrying out the experiments Sutton suspended a small closed glass bulb of about 10 cm.³ capacity from a balance and lowered the bulb into an iron cylinder (surrounded by ice) which was then filled with mercury; the bulb was afterwards raised into a heat-insulated chamber and weighed at 0 deg. C. The chilling bath was now replaced by a steam chamber, and the bulb re-weighed in the steam; the mass m of water condensed on the bulb was thus determined. In the second stage of the experiments the bulb was opened, nearly filled with water and re-weighed after closing; the difference between the two weighings $(m_1 - m)$ gave the condensation due to the water charge in the bulb. All weighings were made to the fourth decimal; the condensation on the empty bulb amounted to 0·36502 grm., that on the filled bulb to 1·074425 grm.; the corrected difference $(m_1 - m)$ was 0·71181 grm., and the water charge 3·8360 grm. The value deduced for the heat of vaporisation L was 538·89 mean calories, and a second series of determinations, made with another bulb, yielded 538·86 grm.; the mean value for the heat of vaporisation of water at 100 deg. C. was 538·88 calories. Extraordinary precautions had, of course, to be used to prevent condensation of water on the suspension system (which comprised a small windlass) and other errors, among which was the loss of heat by radiation from the bulb to the wall of the steam chamber. This loss, leading to an increase in the condensation, was effectively prevented for a period of least 20 minutes by surrounding the bulb with a cylindrical shield of glass. By comparing his value for the heat of vaporisation, determined in calories, with that of Henning (Reichsanstalt), who determined it in electric units, Sutton arrived at the value $4{\cdot}185 \pm 0{\cdot}002$ joules for the mechanical equivalent of heat (Philosophical Magazine, January, 1918, pages 27 to 29). He pointed out that this value 4·185 was in excellent agreement with the determinations of Schuster and Gannon, Callender and Barnes, and others; whilst Joule's first value had been 4·173, and the later determinations (after 1905) by Crémien and Rispail (4·189), and by Henning himself (4·188) gave higher values. From a communication by W. Jaeger and H. von Steinwehr, of the Reichsanstalt, in the Annalen der Physik, of April 4, 1919, it appears, however, that Henning and Sutton are likewise in close agreement. When publishing his results Henning pointed out that his final figures were preliminary, and that they might require a small correction owing to the uncertainty of the electric units which were then undergoing international revision. The standard resistance coil, on which Henning had relied, was subsequently found to have changed, moreover. The recalculated value of Henning 4·1842 joules, was in 1915 communicated to the Berlin Academy of Sciences; this publication had evidently not reached Sutton when he wrote his second paper. The recalculation was based upon the international ohm. and on the value 1·0183 volt for the electromotive force of the Weston normal cell at 20 deg. C. Owing to the uncertainty of some electric units all the electric determinations of the mechanical equivalent of heat are a little doubtful, as Jaeger and Steinwehr remark; they consider Bousfield's value of 1911, 4·179, as most reliable from this point of view, though lower than the generally accepted values.

LITERATURE.

Electricity and Magnetism for Engineers. Part I., Electric and Magnetic Circuits. By HAROLD PENDER, Ph.D. London: The Hill Publishing Company, Limited. [Price 15*s.* net.]

THIS text-book, as its title correctly implies, is essentially a work for engineers and students of electrical engineering. In marked contrast with many of the older text-books on this subject is the complete absence from it of matter relating to pith balls and sealing wax, obsolete forms of primary cells, frictional electric machines, &c., which although they have played an important part in the development of the subject, are now of historical interest only. Throughout the present work the author's intention has been to describe the more important magnetic and electric phenomena, and to give exact quantitative statements of the fundamental laws or principles underlying these phenomena, afterwards applying the laws to some of the simpler problems in electrical engineering. After defining the mechanical and electrical units employed, and explaining the methods of measuring the latter, he deals, on the above-mentioned lines, with power transmission, resistance of conductors, magnetic flux, hysteresis, eddy currents, self and mutual inductance, and the force on a conductor in a magnetic field. Numerical examples, of a practical nature, are given to illustrate each step in the reasoning, and the student who works conscientiously through all of these can hardly fail to obtain a thorough grasp of the subject. Generally speaking, the text is clear and accurate, but there is room for improvement in the author's definition of the resistance of a conductor. This, he states, "is that quantity by which the current in a conductor must be multiplied in order to give the rate at which heat energy is developed." The slip, however, should be easily detected by the careful student as Joule's law is correctly given in the matter immediately preceding the above definition. In another case the terminal voltages of a source and a receiver of electric energy are given as equal to $e - r i^2$ and $e + r i^2$, respectively, but here again the reader is not likely to be led astray. A few of such errors, which seem inseparable from first editions, may even do good by causing the student to look more carefully into the matter relating to them, but it must not be thought that we are recommending their intentional inclusion for this purpose. We also differ from the author when he states that the term "kelvin" is frequently used in this country to designate a kilowatt-hour. The majority of electrical engineers, we feel sure, have never heard the name in this connection. However, the few defects we have mentioned detract but little from the value of the work, which is certainly a very useful addition to the literature of the subject. The part devoted to magnetic calculations, especially, will form an excellent introduction to the study of the design of direct-current machines.

The Metallurgists' and Chemists' Handbook. By DONALD M. LIDDELL, Captain, Sig., R.C., A.S., sometime Managing Editor of the *Engineering and Mining Journal*. Second Edition. New York: McGraw-Hill Book Company, Inc. London: Hill Publishing Company, Ltd. [Price 20*s.* net.]

THE compiler of a handbook for the metallurgist and chemist has, to a certain extent, also to satisfy the demands of the engineer and electrician, and his work will have to combine some of the features of an engineer's pocket book with chemical and metallurgical data. Mr. Liddell discharges his difficult task by devoting 52 pages to mathematics; 150 pages to physical constants; 70 pages to chemical data; 37 pages to sampling, assaying and analysis; 64 pages to ore dressing; 10 pages to cyanidation; 27 pages to fuel and refractories; 36 pages to mechanical engineering and construction; 34 pages to general metallurgy; 7 pages to organic chemistry (a summary of typical constitutions); 9 pages to first aid, and 15 pages to the alphabetical index. We have left out the second section of 22 pages on prices and production statistics (mainly American) which seem to be singularly out of order in that place. In other respects we have adhered to the order of the table of contents of the volume, which runs into 656 pages of a small, but clear type, on good paper—a point worth mentioning. In addition to this table of contents there is only the index, which might be more complete. A detailed table of contents would have made it a little easier for the reader to become familiar with the volume, which certainly contains a large mass of useful information, not always, perhaps, arranged in the best way. In the Physical Constants melting-points come a long way behind boiling-points; there are some figures on strains on substructure (permissible loading of foundations) interposed between air-compression data and cost of metallurgical plants. These figures are not mentioned in the index, in which we also looked in vain for the "attempt made to present the new concepts concerning the constitution of matter," to which the preface draws attention. We found the respective 11 pages—which would hardly be missed, though they are quite acceptable—under the heading "Structure of Atoms" (not mentioned in the index either) in the section on Chemical Data. When Avogadro's law was stated, the value of Avogadro's number should have been added.

This second edition of the Handbook is described as being revised and enlarged. The first edition was published in 1916, and we have hardly noticed any literature references later than 1915. The preface also states that much that the author had intended to print on war activities (information on alloys and toxic gases) is at present forbidden ground; for this reason explosives have been ruled out. The few tables on barometer corrections are in centimetres, millimetres or inches, but do not explain the millibar, which is now legal in the United States, we believe. The notes on nickel-cobalt-copper smelting are poor, and a reference to Schnabel on that subject is of little value. Handbooks of miscellaneous character will always fluctuate in value in their different divisions. Very valuable is the definite information generally given that certain processes, furnaces, and apparatus are or were in use in works mentioned, and we can on the whole well understand that there was so early a demand for a second edition of Mr. Liddell's Handbook. It is really a hand-book which will fit into a pocket.

The Natural Organic Colouring Matters. By Professor ARTHUR GEORGE PERKIN, F.R.S., F.I.C., of Leeds, and Dr. ARTHUR ERNEST EVEREST, F.I.C., of the Wilton Research Laboratories. London: Longmans, Green and Co. [Price 28*s.* net.]

THE technical value of natural dye-stuffs has much decreased of late, except in countries which know little of manufacturing works. Yet some natural dyes are still in extended use in the western hemisphere, though one hardly remembers what fustic and Persian berries may be. Progress has also been made in the utilisation of some natural colouring matters as starting points for building up synthetic dyes of higher values, and the natural dyes themselves, though not necessarily harmless, are finding more favour in the colouring of foods. Even this advance, however, has been more marked in Germany than over here, and the text-books on the subject have come from that country. The last English publication in this field, the "Handbook of Dyeing and Calico Printing" of 1874, was the compilation of Sir William Crookes; one has almost forgotten that Crookes ever worked in colouring matters, and the scientific development of the chemistry of dyeing belongs to the subsequent decades. In this development the authors of "The Natural Organic Colouring Matters"—and Dr. A. G. Perkin, one of three sons, all chemists, of the late Sir William H. Perkin, in particular—have taken a pre-eminent share in this country. Dr. Perkin is Professor of Colour Chemistry and Dyeing in the University of Leeds, and Dr. Everest was head of the Department of Coal-Tar Chemistry at the Technical College of Huddersfield. In this volume of 655 pages it is more the investigators of the fascinating complex constitutional problems, who speak, than the practical dyers.

Substantive dye-stuffs are comparatively rare in Nature. But almost every plant possesses some tinctorial properties, when used with mordants, and the use of mordants is ancient; they were mostly metallic sulphates, though not recognised as such. It is their low concentrations and want of fastness which have rendered most natural colouring matters unfit for competing against the concentrated artificial dyes. In the plant the colouring matter is more frequently found in the flowers and leaves than in the fruit, stem, bark and roots; when present in the latter, however, as in logwoods, quercitron bark and madder, it has more time to accumulate than in the short-lived flowers and leaves. Colourless or yellow flowers like white clover and the yellow primrose give yellow shades on aluminium mordants owing to the presence of flavone or flavonal glucosides. These same sub-

stances occur in red, blue and violet flowers, and they then dye the mordant green, because there is present also another colouring matter, anthocyanin, which was studied by Willstätter and Dr. Everest, and which alone would produce a blue colour. But the yellow glucoside is rarely responsible for the yellow shade of the flower, which is due rather to carotin and similar substances, themselves devoid of dyeing properties. Some white sweet peas, one remembers in this connection, do not breed true; the parent flowers may be all white, whilst the offspring develop pink and purple petals; so far the chemist cannot be of much use to the biologist in the elucidation of the mysteries of propagation, we are afraid.

It took more than half a century to work out the chemistry of the most important colouring matters of madder, the roots of the herb rubia tintoria, a plant which the ancient Indians and Egyptians cultivated for its tinctorial value. With the crusades, the cultivation spread over to Europe, where the roots became known as *alizari*. Two dyes, alizarin and purpurin, were isolated from the root a hundred years ago, though not in the pure condition, but the synthesis of alizarin was only made possible in 1868 when Graebe and Liebermann showed that it was a dihydroxy-anthraquinone. Chevreul worked on old fustic (the wood of the tropical tree chlorophora (or morus) tinctoria) and young fustic (wood of rhus cotinus) in 1814, isolating morin and fustin (later called fisetin), after having prepared hæmatoxylin from logwood in 1810; he also studied the indigo plants. While the fustics are still utilised, natural indigo seems doomed. Gone is also the importance of kermes, the most ancient dye-stuff on record, the authors of this volume inform us, the tola of the Hebrews, the scarlet dye of the Phœnicians, and the coccus of the Greeks; kermes is the name of an insect found on the quercus coccifera, the females of which resemble blue berries covered with a whitish powder. Old Flemish tapestry was dyed with kermes.

The replacement of kermes by synthetic dyes did not ruin any industry, nor did Friedländer's final revelation in 1906 of the synthetis of another famous ancient dye, the Tyrian or Byzantian purple. That dye was obtained from small marine molluscs of the murex species, large heaps of the shells of which have been found near Pompeii and Athens. From a small cyst the animal secretes a yellowish pus which, applied to linen, turns yellow, blue and finally a brilliant crimson, while spreading a very offensive smell. This peculiar change is said only to take place in sunlight, not in moonlight, nor in artificial light, though also in a vacuum and in atmospheres of hydrogen and nitrogen; in the dark it can be delayed for years, it is stated. Schunck obtained, in 1879, from 400 of the molluscs, 9 milligrammes of a colouring matter resembling indigoten which by a tedious, highly unsavoury research, conducted in the zoological station of Triest, Friedländer proved to be dibromindigotin.

To a slight extent some sea snails are still utilised for dyeing, as are saw wort, dyer's broom, onion and walnut skins and alderberries. More important are the logwoods, Campeachy and Brazilwood, and the soluble red woods which yield their colouring matter readily to boiling water, whilst the barwoods and camwoods from West Africa and Sander's wood from India, are not so easily extracted. The logwoods have recently found formidable rivals as blacks for cotton dyeing in the sulphide blacks. The old fustic was, like logwood, exported from Cuba, Jamaica and Brazil in logs. The alkanna (alhenneh of the Arabs) is a root giving yellow dyes. Cochineal—yielding crimson and scarlet chiefly for silks and wool, now replaced by azo-scarlets—consists, like kermes, of the dried bodies of small insects living on certain cactus. The similar lac-dye is produced by another insect, the coccus lacca, which exudes a viscous fluid, the sticklac. Turmeric, or Indian saffron, comes from the roots of some curcuma species yielding curcumin; this substance dissolves in alkali with a brownish colour which turns yellow on neutralisation; "turmeric paper" is henced used as colour indicator. The constitution of litmus, the first colour indicator put into the hands of the chemical student, is not settled yet, curiously enough; the blue colouring matter comes from various lichens, species of lecanora and roccella, which also yield red orcein, the commercial archil or orchil (orseille), which served for "bottoming" or "topping" indigo, the first or last dyeing of the cloth being made with orchil. The chief dye of the old European races, the weld, contains luteolin and is extracted from reseda luteola, which is still cultivated for this purpose; with tin and aluminium mordants luteolin gives pure yellows which surpass other vegetable yellows and most natural colours in fastness. Persian berries are the fruits of various rhamnus shrubs, which are planted also in Southern Europe; the berries are yellowish-green, of pea size and bitter taste, and look shrivelled up; tin mordants bring out yellow and orange, other mordants green shades, and the berries are still utilised in calico printing. The catechus or cutches, the botanical origin of some of which is uncertain, also give fast browns on cotton and wool, and are used for silk-weighting. The tannins are not considered dye-stuffs proper; they are of great service, however, in the production of blacks and greys, and are therefore discussed in this volume.

Dr. Perkin and Dr. Everest, we said already, write for the research chemist rather than for the manufacturer of dyes and the dyer, who will find references, however. Their compilation is an excellent book, amply stocked with references, thoroughly up to date, and provided with good indices. The general reader might like to have more information upon applications; but the subject is sufficiently wide as treated. One impression may force itself upon the reader. Not a few of these natural dyes used to maintain, or help to maintain, thousands of poor people in all parts of the world, who are now, impoverished by the decay of their small industries, expected to buy what they used to produce by their own profitable labour. On the other hand, more is done than ever before for the development of natural resources. It generally means, however, that raw materials, originally of very low value, are shipped far away to big works to be transformed into products of higher value. Huge industries have been built up in this way, but the country of origin shares little in the advantages realised. We do not wish to raise a sentimental question. One may ask, however, whether it would not be in the general interest finally if more were done to encourage small native industries.

BOOKS RECEIVED.

The Civil Engineer's Pocket Book. By JOHN C. TRAUTWINE. Revised by JOHN C. TRAUTWINE, Junr., and JOHN C. TRAUTWINE, 3d. Twentieth edition. Philadelphia: Trautwine Company; London: Chapman and Hall, Limited. [Price 6 dols.]

Elements of Graphic Dynamics. An Elementary Text Book for Students of Mechanics and Engineering. By EWART S. ANDREWS, B.Sc.Eng.(Lond.). London: Chapman and Hall, Limited. [Price 10*s.* 6*d.* net.]

Royaume de Belgique. Ministere de l'Industrie, du Travail et du Ravitaillement. Rapports Annuels de l'Inspection du Travail. 19 me Année (1913). Brussels: J. Lebègue et Cie. [Price 7.50 francs.]

Applied Optics. The Computation of Optical Systems. Being the "Handbuch der angewandten Optik" of Dr. ADOLPH STEINHEIL and Dr. ERNEST VOIT. Translated and edited by JAMES WEIR FRENCH, B.Sc. Two Vols. London: Blackie and Son, Limited. [Price 12*s.* 6*d.* net, each volume.]

Railway Stores Methods and Problems. By W. H. JARVIS, F.S.S. London: *The Railway Gazette.* [Price 4*s.* net.]

Reports of the Progress of Applied Chemistry issued by the Society of Chemical Industry. Vol. III, 1918. London: The Society of Chemical Industry.

Modern Electrical Engineering. Prepared under the Editorship of MAGNUS MACLEAN, M.A., D.Sc. In six volumes. Vol. I. *Electric Measurements: Meters; C.C. and A.C. Generators.* Vol. II. *D.C. and A.C. Motors; Transformers; Storage Batteries.* Vol. III. *Switch Gear; Electric Mains; Transmission; Lighting and Wiring; Arc Lamps.* Vol. IV. *Incandescent Lamps; Electric Tramways.* Vol. V. *Electric Railways and Vehicles; Steam Boilers and Engines, Condensing Plant; Electro Chemistry, &c.* Vol. VI. *Telegraphy; Telephony; Electricity in Mining; Electric Cranes.* London: The Gresham Publishing Company, Limited. [Price 12*s.* 6*d.* per volume.]

Air Navigation: Notes and Examples. By Instructor-Captain S. F. CARD, B.A., R.N. London: Edward Arnold. [Price 10*s.* 6*d.* net.]

Smithsonian Institute. Report of the Progress and Conditions of the United States National Museum for the Year ending June 30, 1918. Washington: Government Printing Office.

A Treatise on Roads and Pavements. By IRA OSBORN BAKER, C.E., D.Eng. Third Edition, re-written and enlarged. New York: John Wiley and Sons, Inc.; London: Chapman and Hall, Limited. [Price 19*s.* net.]

JAPANESE TRADE.

THE Department of Finance, Tokyo, have sent us a copy of their eighteenth financial and economical annual report, dated 1918, which gives interesting figures on the trade and industry of Japan for a number of years.

Leaving out of consideration in the following brief review all data which cover purely financial questions, data which are contained in a series of tables and are illustrated in several tinted diagrams applicable in most instances to fifteen consecutive years, we extract a few figures concerning mainly the mineral production and the general trade of the country.

In the year 1917, the gold production reached a total value of 938,764*l.*; the figure for silver was 1,194,640*l.* The copper production was 103,270 tons, valued at 11,869,200*l.*, and the lead production 15,550 tons, valued at 566,100*l.* Of pig-iron there was produced 121,300 tons, valued at 1,207,300*l.*; of steel, 364,200 tons, valued at 8,256,900*l.*; and pyrites, 119,500 tons, valued at 104,000*l.*; iron antimony, 6,620 tons, valued at 317,300*l.* The coal output amounted to 26,361,420 metric tons, for a value of about 14,000,000*l.* The production of sulphur reached 116,200 tons, valued at 476,600*l.*, plus 13,400 tons of ore, valued at 10,400*l.* That of crude petroleum was 99,000,000 gallons, valued at 1,900,000*l.*, plus 895,000 cub. ft. of actual gas, valued at 82,400*l.*

The latest figures for coal consumption are those covering the year 1916, during which there were supplied to Japanese ships 4,388,329 metric tons, to foreign ships 932,881 metric tons, for railways 1,993,461 metric tons, to factories 10,426,076 metric tons (as against 4,420,545 metric tons in 1907), for salt manufacture 838,376 metric tons, a total of 18,579,123 metric tons, out of a total output for the same year of 22,901,580 metric tons. The coal exports, still in 1916, were 3,016,947 metric tons, and the imports 556,110 metric tons.

At the end of 1916, there were in Japan 12,612 factories worked by motors (as against 5,207 in 1907). The census of the prime movers driving these factories is in round numbers the following: 5,407 steam engines for about 328,000 h.p.; 737 steam turbines for about 142,000 h.p.; 1,665 gas engines and about 39,000 h.p.; 572 oil engines and about 7,000 h.p.; about 2,000 various water wheels and turbines, developing a total of about 380,000 h.p., 3,550 electric motors using current generated in the same factories and developing about 100,000 h.p., and about 13,000 electric motors using current supplied from outside sources and developing about 200,000 h.p. The number of factories having no motive power was 6,687, making a total of 19,299 factories, employing 458,632 male operatives, 636,669 female operatives, a total of 1,095,301 operatives (as against a total of 543,292 operatives in 1907).

By far the greater number of factories in Japan are those for the manufacture of textiles, the figure for which, for 1916, is 9,392; there are besides 1,857 machine and iron factories (including engine building, shipbuilding and carriage works, tool works, foundries, metal and metalware work), 2,263 chemical works, 2,486 food and drink factories (breweries, sugar mills, and so forth), 3,069 miscellaneous factories (including printing and publishing, wood and bamboo work, &c.), and 232 special factories which latter cover the electrical industry, the gas industry and metal refineries.

Also by far the greater number of operatives—1,095,301 in all as above stated—are employed in the textile factories, there being in these latter 97,020 male operatives, 542,418 female operatives, a total of 639,438, also during 1916.

In 1916, the electric concerns for the supply of current for power and lighting numbered 520 (as against 112 in 1907) and they supplied 175,532 kw. for power and 200,400 kw. for lighting purposes. The figures for the gas enterprises only cover down to the year 1915, when there were 91 companies, as against 6 in 1906.

The number of applications for patents in 1917 numbered 5,564 on behalf of Japanese and 918 on behalf of foreigners, a total of 6,482. The number of letters patent granted were 1,093 to Japanese, 355 to foreigners, a total of 1,448. Among the foreign countries, Great Britain entered for 345 applications and had 119 grants, other figures being United States 334 and 156, France 55 and 15, Holland 13 and 4, Switzerland 17 and 12, Sweden 70 and 29, Norway 18 and 7.

There were in 1916 throughout the country 5,942 industrial companies, being joint stock companies, and limited and ordinary partnerships, having a total paid-up capital of 105,710,800*l.*; 10,551 commercial companies having a total paid-up capital of 107,142,400*l.*; and 1,241 transportation companies, the total capital of which was 27,379,400*l.*

The trade of Japan is illustrated in a table which gives the total value of exports and imports of

merchandise from the year 1882 down to August, 1918. In 1913, the excess of imports over exports amounted in value to 9,697,100*l.* in round figures; in 1914, the excess of imports over exports was only 463,400*l.* The situation then changed completely and exports exceeded imports for 1915 by 17,585,700*l.*, in 1916 by 37,104,000*l.*, in 1917 by 56,719,400*l.*, and from January to August, 1918, by 10,560,800*l.* The total value of the exports for 1917 was 160,300,500*l.*; of which 70,411,100*l.* apply to Asia—about half of this latter figure representing exports to China; 33,518,250*l.* being applicable to Europe—the greater part of 20,264,600*l.* representing exports to Great Britain; 50,356,000*l.* being the value of the exports to America, of which the United States took 47,853,600*l.* in value; 5,402,500*l.* being the value of the exports to Australia, which took goods for a value of about half the latter figure—to Cape Colony and Natal, Egypt and Hawaii. The table gives, further, two comparatively small sums to "other countries" and to "unknown destinations." The total value of the commodities imported into Japan also for 1917, was 103,581,100*l.*, divided in the main as follows: Asia 47,551,800*l.*, the principal component figures being 22,394,100*l.* from British India, and 13,327,100*l.* from China; Europe 8,217,600*l.*, in which figure Great Britain enters for 6,330,400*l.*; America 37,678,200*l.*, the greater part, or 35,970,500*l.*, representing imports from the United States; there being, further, imports to the value of 3,293,400*l.* from Australia; 1,885,100*l.* from Cape Colony and Natal; 1,090,700*l.* from Egypt; besides entries under Hawaii, temporary warehouse, and unknown origin. All the above figures for exports and imports do not include gold and silver coins and bullion, and apply to Japan proper only.

The steamships entered from foreign countries were the following in the year 1917:—

	Number.	Tons.
Japanese	7,463	14,178,552
Chinese	52	24,771
British	625	2,620,796
French	68	271,330
Rusian	566	712,099
Danish	37	110,956
Swedish	12	32,475
Norwegian	68	207,141
United States of America	169	475,522
Other countries ...	219	773,227
Total	9,279	19,406,869

The last year showing the entry of German ships in Japan was 1914, when the ships numbered 355, for 1,281,973 tons; in the same year, 1914, the British ships which entered Japanese ports numbered 1,875, for 6,697,859 tons. The highest figures for Great Britain since 1903 were reached in 1913, when 2,166 British ships entered, having an aggregate of 7,228,460 tons; in 1913, the German ships entered numbered 466 for 1,679,104 tons.

The list of increased exports for the year 1917 as compared with 1916 is headed by raw silk, the increase over 1916, in value, being 8,811,800*l.*; raw silk was largely in demand from both Europe and America, due partly to the fact that the output in silk-producing centres outside Japan was poor. The largest consumer, as formerly, was the United States, followed by France, Great Britain and Italy. The next item on the list is steamships, the increase in the exports of which in 1917 over 1916 amounted to over 8,000,000*l.*, this being accounted for by a scarcity of vessels and a brisk demand for them from both Europe and America.

The list of increased imports for the year 1917 as compared with 1916 is headed by bar iron, the increase over 1916, in value, being over 10,000,000*l.* There is also an increase in the value of machines and machinery imported to the extent of over 1,600,000*l.* These items were largely in demand in shipbuilding and other enterprises which had undergone a sudden development in Japan since the war.

The report deals separately with Korea, Formosa, Saghalien and the Kwantung Province. The principal mineral products of Korea are gold, silver, zinc, copper, lead, iron, graphite, coal and tungsten ore, the country being especially rich in gold, iron, graphite, and anthracite. The principal mining product of Saghalien is coal, next to which come alluvial gold, petroleum and iron pyrites. There are three important coalfields in Saghalien, the Northern, the Middle and the Southern coalfields; the greatest of these is the Middle coalfield which extends over 60 miles, the North varying from 1 mile to 3 miles. Among the most promising of the manufacturing industries of the Kwantung Province are those of cement, brick, lime and glass.

MIDDLESBROUGH PIG-IRON SHIPMENTS.—A leaflet recently issued by Messrs. William Jacks and Co., 5, East India Avenue, shows that the Middlesbrough and Skinningrove shipments in June were, coastwise 1,950 tons and foreign 14,360 tons, a total of 16,310 tons only, as compared with 22,622 tons last May, 44,047 tons in June, 1918, and 60,638 tons in June, 1917.

ON THE UTILISATION OF STEEL TURNINGS IN THE BLAST FURNACE.

THE fact that the blast furnace can deal with iron waste, steel scrap and, notably, steel turnings, was well-known before the war, says Mr. Tripier, a French metallurgist, in the *Comptes Rendus de la Société de l'Industrie Minérale*, but the war, he adds, has furnished an occasion for the systematic utilisation on a large scale in the blast furnace of the latter waste product.

At the commencement of 1915, an ironworks in the North of France lacked further supplies of Spanish ores for the manufacture of hematite pig-iron; the temporary loss of the Briey basin also cut off the usual supply of the best grade of ironstone hitherto available for the making of basic pig-iron. In these circumstances the works were asked to utilise steel turnings in the blast furnace, since these were being obtained in very large quantities in the munitions factories and were not being diverted to a corresponding extent to the steelworks for remelting.

At first, there was added to the burden of one furnace in blast at the time, 1915, and producing hematite pig-iron, a proportion of steel turnings of barely 10 per cent. of the weight of the pig-iron produced. But owing to the large proportion of purple ore briquettes, high in sulphur, also used, the results in the beginning were not very satisfactory, and generally when the working of the furnace became irregular, the addition of steel turnings was stopped. On re-starting, however, the tendency each time was to increase the proportion of steel turnings added to the burden, and after a short while an attempt, which proved successful, was made not to eliminate the turnings in the event of irregular working. In the commencement of 1916 four furnaces were put in blast, and in each of these the proportion of turnings utilised was raised to 20 per cent., 30 per cent. and 50 per cent. of the weight of pig-iron produced. Then the supply of ironstone failed completely for a time and an attempt was made to use turnings exclusively; this was quite successful. In 1917 the works had at their disposal a very large quantity of turnings, and with three furnaces, two hematite and one basic, they had during three months a perfectly regular working, each blast furnace producing double the quantity of pig-iron which would have been obtained with good ironstone. The monthly consumption of turnings exceeded 25,000 tons for the three furnaces.

The works in question being remarkably close to the front, there were frequent stoppages due to bombardment, to damage to the water, gas or blast pipes, or to the blowing engines. Stoppages of several hours, even when they occurred frequently, did not give rise to any appreciable irregularity in the working, whilst stoppages of several days sometimes caused scaffoldings or blocking of the hearth, but such accidents were less frequent and more easily remedied than those which would have occurred in similar circumstances using excellent ironstone. These results are attributed, in part, to the practice of leaving the throat of the furnace at a standstill in communication with the gas from the other furnaces in activity, however long the period of standstill, by which means matters were greatly simplified; it is only necessary to cut off the blast from the furnace in question and to close all communication between the tuyeres and the blast pipe. The furnace thus at a standstill cools rather rapidly, for the slow consumption of the coke it contains does not keep up the temperature. For re-starting it suffices to blow with hot air blast from the Cowper stoves, these being previously heated. It occurred once, however, that the above precaution could not be taken, nor could the furnace be carefully damped down, the cause of the stoppage being an accident to the lift; when the furnace was re-started without any preliminary preparation, after a period of inactivity of eight days, a serious scaffolding was ascertained. Soundings showed that thick layers had been formed in the belly of the furnace and especially in the shaft, up to 60 in. in thickness and consisting exclusively of red-hot turnings mixed with dust and coke ash. The masses were brought down by a few charges of dynamite and twenty-four hours afterwards the furnace worked normally. Very high proportions of turnings have also been used in the firing-up charges of blast furnaces, and the starting of the furnaces so charged has been remarkably easy. The furnace walls are not affected by the use of turnings in large quantities, as has been evidenced in the case both of new blast furnaces and of others whose previous period of activity had been more or less long.

The following are some of the burdens worked to, per metric ton of pig-iron produced:—

1. *Hematite Foundry Pig-iron.*
Si, 2.50; Mn, 1.00; S, 0.04; P, 0.08.

	k.
Coke	1,275
Spanish ore	2,200
Limestone	900
Coke	1,300
Purple ore briquettes	1,400
Tap cinder	100
Spanish ore	600
Mn. ore	6
Limestone	800
Coke	575
Turnings	1,000
Tap cinder	100
Ferro-Mn slag	40
Silex stones	20

2. *Spiegel Iron.*
Si, 0.7; Mn, 12.00; S, 0.02; P, 0.1; C, 4.4.

	k.
Coke	1,275
Purple ore briquettes	1,400
Mill scale	150
Spanish ore	350
Mn. ore	350
Limestone	750
Coke	725
Turnings	900
Mn. ore	275
Limestone	200

3. *Basic Pig-iron.*
Si, 0.3; Mn., 1.25; S, 0.08; P, 2.10.

	k.
Coke	1,250
Normandy ore	2,200
Mn. ore	70
Basic slag	80
Limestone	1,100
Coke	1,075
Briey ore	1,800
Normandy ore	800
Mn. ore	60
Basic slag	60
Limestone	150
Coke	450
Turnings	950
Normandy ore	150
Basic slag	260
Mn. ore	20

The latter burden showed a loss in the slag of P and Mn. rather above normal. The burden containing a large proportion of purple ore briquettes for the production of hematite pig-iron, and that containing solely Normandy ore for the production of basic pig-iron, occasionally led to difficulty in the working; all the others worked smoothly. The author gives the analysis of the materials forming the various charges.

From the commercial point of view, he states the following: Above are given two instances of basis pig-iron production, in one of which the coke consumption is 1,250 k. per metric ton of pig-iron, and in the other 450 k. per metric ton. In the latter case, using steel turnings, the normal production of a blast furnace burning 200 tons of coke per day is 445 tons of pig-iron, and in the former case the production of pig-iron is 160 tons. It can, therefore, be advantageous to utilise turnings in blast furnace practice even if the cost price of a ton of pig-iron produced be not decreased by their utilisation.

After additional data on the working of the blast furnaces in different circumstances, for example, with charges containing 95 per cent. of turnings, then changing over to burdens formed exclusively of ironstone, Mr. Tripier adds that the abundance of steel turnings during the war led to attempts being made to turn this waste produce to account. The cupola, probably, has not yielded good results, whilst the electric furnace entails a high consumption of current per ton of output and a correspondingly large coal consumption if the current is generated in a steam-driven power station. He makes reservations in regard to the prevailing opinion according to which steel turnings find their real scope for utilisation in the open-hearth furnace. Steel turnings, he adds, are a material long and difficult to charge through the door of the open-hearth furnace. Once in the furnace the mass of turnings sinks down and being no further penetrated by the gases it is badly heated up. Working suffers thereby, the furnace has a low heat efficiency and the output is lowered. For a satisfactory use in the open-hearth furnace, the turnings have to be bundled or briquetted. Bundles of turnings are not sufficiently dense for exclusive use in the charging of an open-hearth furnace; a certain proportion only can be charged and they are less expensive to make than briquettes of turnings. Both the bundling and the briquetting plants, however, are costly to put down, and costly also from the point of view of labour and maintenance. Comparative figures are quoted of the cost of utilising the steel turnings in the open-hearth furnace, and in the Bessemer or basic converted, *via* the blast furnace, and the author concludes as follows: In the case of an ironworks owning all the necessary plant and having turnings, also cast-iron and steel scrap to be disposed of, the question to be decided refers to the apparatus in which this waste should be treated by preference, the choice lying between the blast furnace, cupola, open-hearth furnace, Bessemer converter, basic converter, and electric furnace. A large portion should be set apart for treatment in the blast furnace.

THE MACHINE TOOL TRADES ASSOCIATION.—The Executive Committee of this association held meetings on May 28 and June 25, when—among other points—it was decided to recommend to the British Engineering Standards Association that they should ask the American Institute of Mechanical Engineers to adopt the same standards for T-slot cutters as those which may be ultimately decided upon for this country. It was decided also to ask the British Engineering Standards Association to make a preliminary investigation into the standardisation of gears. It was decided, further, to ask the Federation of British Industries to take up the question of patents as affected by the geographical changes due to the war. Arising out of a letter from the World Trade Club, it was resolved that in the opinion of the committee the adoption of the metric system was not practicable on account of the enormous expenditure involved. The following resolution was unanimously adopted: "In the opinion of the Executive Committee of the Machine Tool Trades Association it would be contrary to the best interests of the country to nationalise the coal mines, railways and electricity supply, or any other resources or industries."

SOME DEVELOPMENTS IN AIRCRAFT DESIGN AND APPLICATION DURING THE WAR.*

By the Right Hon. Lord WEIR OF EASTWOOD, P.C., Honorary Fellow.

ANY attempt to review the progress or development of aviation during the war, and to confine such a review to the permissible limits of a paper, involves a mere indication of some of the more salient features of the development. Moreover, it is difficult to confine any such review entirely to the scientific or engineering aspect of the problem, on account of the peculiarly close association of the technique of construction with the technique of use. The war development of a technical product, such as an aeroplane, necessarily comprises the rapid embodiment of field experience in the design and production of *materiel*, and this compelling influence during the war largely governed the policy of design, supply and production.

In August, 1914, the British Air Services consisted of a naval wing and a military wing, the first controlled by the Admiralty, and the second by the War Office. The naval wing, or Royal Naval Air Service as it was termed, possessed a total of 93 machines, the military wing or Royal Flying Corps possessed a total of 179 machines. In October, 1918, just prior to the armistice, the Royal Air Force possessed over 22,000 effective machines.

For the first two years of the war, the supply organisations for aircraft were departments of the War Office and Admiralty, and no distinct technical departments existed. In January, 1917, the second Air Board, under the chairmanship of Viscount Cowdray, succeeded the original Air Board under Viscount Curzon, and was constituted with additional duties and responsibilities. The Board became responsible for the allocation of aeronautical supplies between the two flying services, and for the supervision of design of all aeronautical material, this latter responsibility being vested in the technical department of the Air Board under Brigadier-General Pitcher. Concurrently with this, the entire responsibility for supply and production of all aircraft *materiel* was handed over by the War Office and Admiralty to the Ministry of Munitions. Toward the end of 1917, a movement in favour of concentrating the entire administration of everything relating to war aviation in a single Government department crystallised in the constitution of the Air Ministry under a Secretary of State for Air, the naval and military air services being amalgamated to form the Royal Air Force in April, 1918.

The establishment of the Royal Air Force as an independent fighting force of the Crown has been thoroughly well justified, and the progress with regard to civil aviation in this country since the armistice is largely due to the existence of a single air authority. Concurrently with the institution of the Air Ministry, the necessity of placing design and supply under a single authority was recognised by the constitution, within the Ministry of Munitions, of the Aircraft Production Department, which assumed full responsibility for all questions of design, supply and production.

An appreciation of the progress made in the domain of supply and production can be obtained from the fact that the average monthly delivery of aeroplanes either from British or foreign sources to our flying service during the first twelve months of the war was 50 per month, while, during the last twelve months of the war, the average deliveries were 2,700 per month. The capacity of the facilities in this country for the production of aeroplanes at the date of the armistice was approximately 3,500 complete machines per month. To those associated with marine engineering, it may be of interest to state that the total horse-power of aero engines produced in the last twelve months of the war, approximated to 8,000,000 of brake horse-power, a figure quite comparable with the total horse-power of the marine engine output of the country.

It may be of interest to recite some of the difficulties encountered in this work, although perhaps the more important of these difficulties were inseparable from the industrial position of the country at the period when the effort towards expansion was made :—

1. The lack of highly-skilled labour, in particular that required for engine production, due to the almost complete absorption of such labour by other and earlier war enterprises.

2. The very high standard of material and workmanship involved so that safety might be ensured on the low permissible weight of the product.

3. The necessity of creating and building up entirely new manufacturing facilities and organisations.

4. The grave influence on production of modifications in design shown necessary by field experience, and the necessity for the rapid embodiment of these in the product.

5. The inability to take the fullest advantages of standardisation, owing to the necessity of making continuous progress in design and performances of machines.

6. The extreme complexity and variety of the elements contributing to the provision and equipment of war aeroplanes.

For example, the provision of satisfactory timber was a continual difficulty—at times an actual menace to the whole development. The textile problem became very grave when the supplies of Russian flax were cut off, and we were compelled to develop additional sources in Ireland and in the Colonies. Acute difficulties were experienced in connection with the development of the chemicals required for dope manufacture. At other times, the supply of machine guns gave much anxiety, while the development of the synchronising gear for these guns necessitated very urgent treatment.

The production of ball bearings involved the provision of new facilities on a colossal scale. The magneto supply involved the building up of an entirely new industry, while the manufacture of the numerous classes of instruments, cameras, radiators and other fittings in each case formed a problem by itself.

The solution of these problems from a production point of view constitutes an outstanding example of the enterprise, courage and ingenuity of British industry. Many mistakes were made, but most of the difficulties were solved and many valuable lessons have been learned. It is a matter of great regret that so many of these enterprises, built up for specific war requirements, cannot be maintained under peace conditions. The development of civil aviation will not, for many years, absorb even a fraction of the war facilities, and a large amount of waste cannot be avoided in the reduction of these industries to a peace-time basis.

The constitution in 1917 of the first Technical Department dealing with aircraft design represented one of the most valuable steps in advance of previous organisation, and the work of this department very largely contributed to the position of technical supremacy held by this country at the close of the war. One of the factors contributing to this success was undoubtedly the adoption of a policy of giving ample freedom of opportunity to private designers, because in the development of a new art, such as aircraft design, any adherence to a single school of thought is dangerous, and the basis of design and experiment should be broadened as much as possible.

In the earlier days of the development the official Government designs of the Royal Aircraft Factory at Farnborough predominated, but the change in policy should not be taken to represent a reflection on the many valuable designs produced at Farnborough. These designs exercised a great influence on all future designs, while the meticulous care in the details, which was the feature of Farnborough practice, has been wholly useful and valuable in its general influence. To the British aircraft designers as a whole, and in particular to the pioneer designers and manufacturers, the greatest credit is due for their courage, skill and ingenuity.

Such is the briefest possible review of the political and administrative conditions under which the developments in war aviation have been carried out. In dealing with the salient features of progress and design two aspects have been separately treated—the aerodynamic aspect and the applicational aspect. As regards seaplanes it is not proposed to deal with their detail development, as this followed generally on the same lines as the aeroplanes with the special adaptations to meet marine conditions.

* Paper read before the North-East Coast Institution of Engineers and Shipbuilders, July 10, 1919.

PART I.—AERODYNAMICAL ASPECT.

Loading.—The outstanding feature desired in war aeroplane performance was expressed generally as the maximum of speed and climb, and it was soon perceived that this feature could be best achieved by a reduction of the weight carried per horse-power. The advance in other aerodynamic features such as wing section, reduction of air resistance, &c., was considerable, but could not be compared in importance with the reduction of the weight per horse-power.

At the beginning of the war, loadings were about 23 lb. per horse-power and 4 lb. per square foot of lifting surface; at the close of the war, nearly 7 lb. per horse-power, and 10 lb. per square foot. This is a remarkable result when it is considered that 7 lb. per horse-power represents the power loading of the total weight of the aeroplane, comprising the engine, its petrol and oil, the aeroplane itself, the pilot and all his fighting equipment. The rate of progress achieved in this development entailed a corresponding large demand on the skill of the pilot, but it was found that the pilot's skill always advanced rapidly as the demands upon it.

Wing Sections.—Wing sections steadily developed from the early sections with their hollow undersides and tops of almost circular camber, to the high efficiency sections of the present day with flat undersides bulged slightly downwards for the spars, and upper surfaces with a quick nose curvature, flattened top and easy run aft.

The illustration, Fig. 1, shows these differences fairly well. It may be noted as an interesting fact, that the Germans at no time made use of a high efficiency section such as the R.A.F. 15 shown.

Air Resistance.—No revolutionary advances have been made during the war in regard to the reduction of air resistance, but the general trend has been the more rigid application of previous knowledge; the conversion of piano wire or cable to streamline wires for main bracing is perhaps the most noteworthy feature. Until quite recently stream-line wires were not adopted by any other country than this, although for fast aeroplanes the gain is considerable—approaching 10 miles an hour on a machine with a speed of 110 m.p.h.

The fuselages were made of fairer shape, and pilots and accessories were more carefully enclosed and protected.

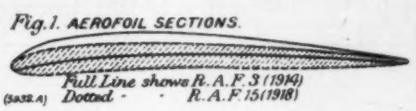
Stresses and Factors of Safety.—At the outbreak of hostilities very little was known of the magnitude of the forces which might occur in flight, and certain more or less arbitrary rules were used in determining the strength of the aeroplane. Many possible methods of failure were never considered, and in some cases it was only through the light shed by certain accidents that progress was made. Certain definite forms of failure which are now always considered and guarded against were only discovered after long and careful examination and analysis of accidents.

When an aeroplane is flying level at a constant speed the air loads acting vertically on the lifting surfaces (wings and tail) must, of course, be equal to the total weight of the aeroplane. Other conditions must be simultaneously fulfilled, but this is the primary one.

This air load on the wings is known as the normal or unit flight load and is the basis of all strength calculations. It will be clear that in order to accelerate the aeroplane, extra forces must be applied, to it, and so in many manœuvres through which the aeroplane is put, extra loads are thrown upon the structure.

These forces are measured in terms of the unit fligh load, and their magnitudes are determined either by calculation or by experiment. Both methods are used, and the advance in knowledge on this question, during the war, has been one of the principal causes of the elimination of practically all accidents which may be genuinely attributed to structural failure, and the great reduction in the percentage weight of aeroplane structures. The experimental method of determining the values of these loads consisted in carrying an accelerometer on an aeroplane. This instrument was self-recording and registered the amount of the accelerations given to the craft during various manœuvres. Developed by Professor Lindemann and Dr. Searle at the R.A.E., its value has been considerable. The illustrations (Figs. 2 and 3) were obtained from one of their autographic records, and these and the attached table will give some idea of the value of the loads which occur during aerial manœuvres. It must be understood that

Fig. 1. AEROFOIL SECTIONS.



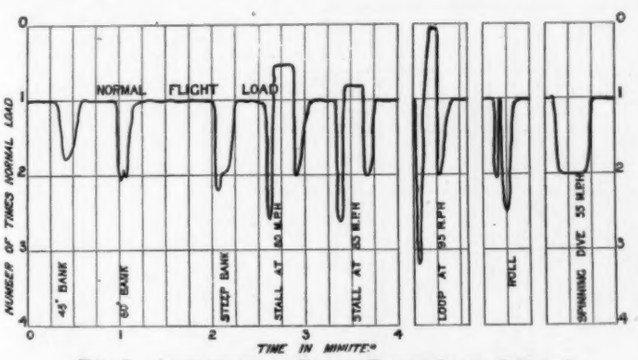


FIG. 2. ACCELEROMETER TESTS. FLIGHT LOADS B.E. 2C.

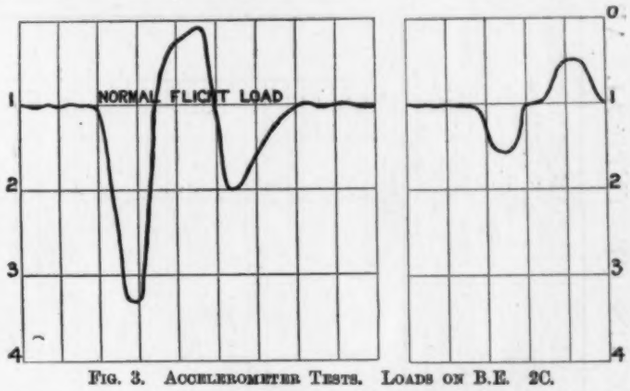


FIG. 3. ACCELEROMETER TESTS. LOADS ON B.E. 2C.

ANALYSES OF WEIGHTS OF TYPICAL AEROPLANES.

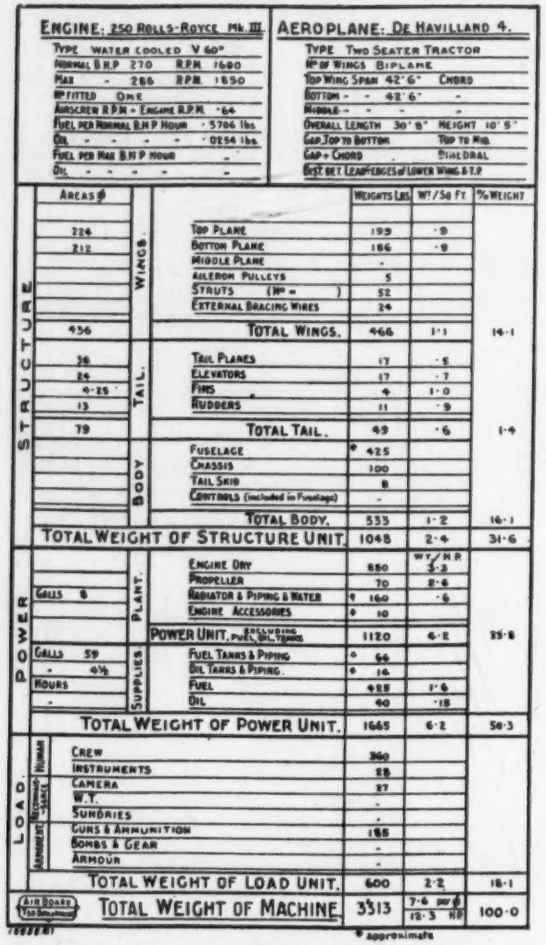

ENGINE: 250 ROLLS-ROYCE Mk. III.
AEROPLANE: DE HAVILLAND 4.
TOTAL WEIGHT OF STRUCTURE UNIT. 1048
TOTAL WEIGHT OF POWER UNIT. 1665
TOTAL WEIGHT OF LOAD UNIT. 600
TOTAL WEIGHT OF MACHINE 3313
* Approximate

FIG. 4. ANALYSIS OF WEIGHT. DE HAVILLAND 4.

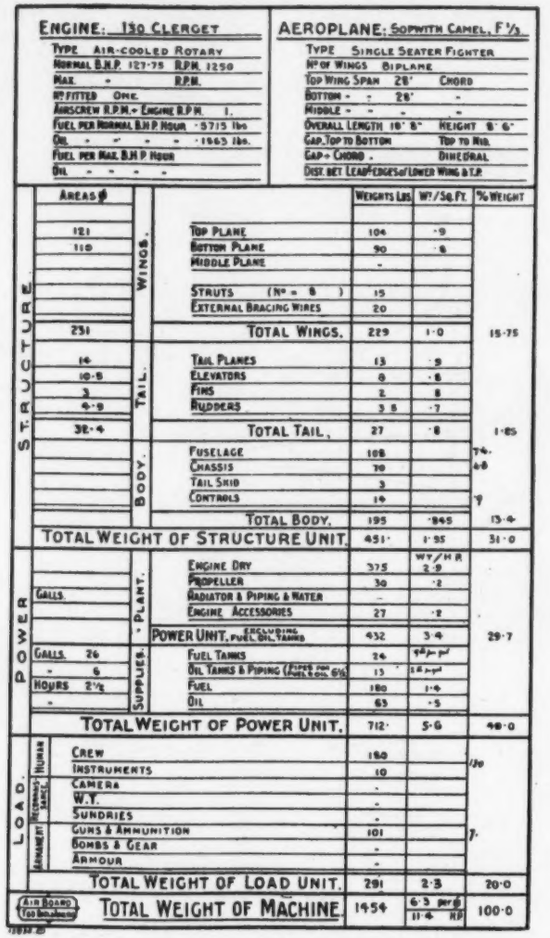

ENGINE: 130 CLERGET
AEROPLANE: SOPWITH CAMEL. F 1/2
TOTAL WEIGHT OF STRUCTURE UNIT. 451
TOTAL WEIGHT OF POWER UNIT. 712
TOTAL WEIGHT OF LOAD UNIT. 291
TOTAL WEIGHT OF MACHINE 1454

FIG. 5. ANALYSIS OF WEIGHT. SOPWITH-CAMEL.

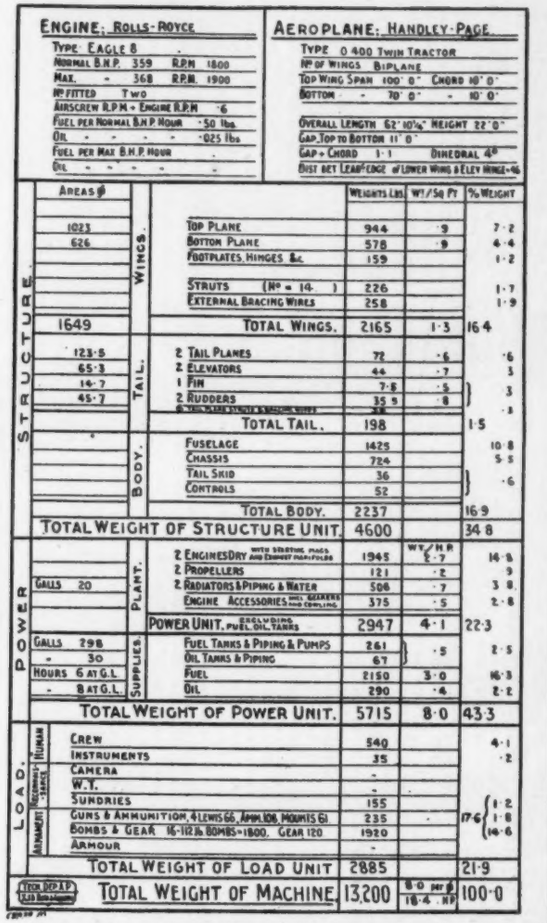

ENGINE: ROLLS-ROYCE
AEROPLANE: HANDLEY-PAGE
TOTAL WEIGHT OF STRUCTURE UNIT. 4600
TOTAL WEIGHT OF POWER UNIT. 5715
TOTAL WEIGHT OF LOAD UNIT 2885
TOTAL WEIGHT OF MACHINE 13,200

FIG. 6. ANALYSIS OF WEIGHT. HANDLEY-PAGE 0/400.

these loads are not the maxima which could occur, but only the maxima registered during the experiments.

Table of Loads.

Ordinary bumpy weather	1½ to ½ normal load.
Spiral dive at 70 m.p.h.	2·8 times normal load.
In a mock fight between S.E. 5 A. and R.E. 8.	3 times normal load was common; at times this increased to nearly 4.

Until all the loads which can possibly occur on an aeroplane are known it is impossible to design an absolutely scientific structure, but considerable progress has been made during the war in this direction, and it is at least possible now to design a structure that will not break in the air except under certain conditions against which the pilot can be warned.

In all other branches of engineering the prevention of failure is obtained by the introduction of a factor of safety, so that the highest possible loading which can occur in the structure stresses the material to only a fraction of its ultimate stress.

With an aeroplane this method is impossible on account of weight limitations, and in consequence a method is adopted of specifying load factors instead of factors of safety.

This method consists of determining—largely as a result of previous experience—what extra loads any particular type of aeroplane is likely to meet under the conditions of flight for which it is intended, and the structure is designed with just sufficient strength to carry these loads, that is to say, when these loads occur the material is stressed either up to its elastic or its ultimate stress. In the usual engineering sense, therefore, the factory of safety under this condition of flight is only one, while the load factor may be from four to seven, *i.e.*, the loads which cause failure are from four to seven times normal flight loads as specified previously.

In aeroplanes of the scout class it has been customary to ask for a load factor of seven, but this only corresponds to a factor of safety of about 0·6. That is to say, the aeroplane by certain manœuvres could be broken in the air. This fact is well known to all pilots, and such a breakage now seldom occurs. It will be seen from the above table that in ordinary bumpy weather the loads were only increased about 1½ times normal.

Since all other increased loads arise from "stunts" it would appear that commercial aeroplanes will seldom have to contend with the heavy loads met with in war flying, and it may be possible on this account to cut down load factors especially on heavier types. The illustration shows the difference between the loads in a loop and loads due to gusty weather upon the same aeroplane.

Analysis of Weights.—As in all forms of science, progress is very largely dependent on the ability to measure accurately the various items and factors. No genius can make up for the neglect of this essential. Once all the factors, whether they be weights, sizes or performances, are accurately measured, it is not so difficult to decide in which direction to proceed. A large amount of attention was given to the careful analysis of the weights of all available aeroplanes, good or bad, and tables were prepared of which samples are given in Figs. 4, 5 and 6.

By a study and comparison of these results in conjunction with the strength of the various aeroplanes, much knowledge of the possibilities of construction was obtained. The interesting fact was arrived at—that for a range of well-designed practical war types, the structural percentage remains roughly constant for aeroplanes of total weight varying from 1,000 lb. to 30,000 lb.

From a theoretical point of view, this is somewhat

surprising because, as is well-known to engineers, the law of dimensions lays down that area increases as the square and weight as the cube of the dimensions, and that this will therefore put a limit on size. In fact, a very eminent aerodynamic theorist, working on these lines several years ago, put the limit of the weight of an aeroplane at about 10,000 lb. There is very little doubt now that aeroplanes of 100,000 lb. are a practical proposition.

Some of the reasons for this apparent theoretical discrepancy may be of interest. One is, that the larger the aeroplane, the more sober is the method of progression. No one wants to loop or do vertical banks on a big passenger aeroplane, and therefore it is not necessary to maintain as high a strength factor on the big type as on the small. As far as actual flying stresses are concerned, it would be possible for an aeroplane with a load factor of only 1½ to be flown without collapse even on a windy day. This statement is only used for illustration, and must not be taken to suggest that a load factor of 1½ would produce a practical aeroplane; it would probably be too weak to stand landing. Another reason for the discrepancy is, that the bigger the aeroplane the more detailed can be the design work, and it becomes possible to use material in a more efficient way.

It is not considered probable that aeroplanes made of wood will increase to a size representing a weight of much more than 40,000 lb., but by the use of high-grade steel and duralumin, it will certainly be possible to go far beyond this limit.

Influence of Tunnel Experiments.—At one time the small scale work carried out in the wind tunnel was regarded as of little practical value; now, judging by the results, I do not think that it would be too much to say that the work which was put into tunnel research, when this work at the National Physical Laboratory was under the direction of Mr. Leonard Bairstow, before as well as during the war, was the real basis of the technical success which we undoubtedly attained, particularly in the aerodynamic field. The data from such work is more useful to the designer from a comparative aspect than for the absolute values obtained, but without their help it is only too easy to stray off into blind alleys leading nowhere except to disappointment.

Some designers have undoubtedly a wonderful facility in guessing the next step to take, but they are too few and far between for responsible authorities to rely solely upon them. In any case such men always work best if there is a solid background of research knowledge behind them, from which they draw sometimes perhaps unconsciously. In 1914 no private firms had a wind tunnel of their own or went in seriously for research. Now there are four or five first-class installations in constant use by designers of the manufacturing firms. As instance of more important results there now exists fairly exact knowledge of the best wing sections, strut shapes, propeller blades and body resistances.

Stability and Controllability.—There are two means of obtaining stability in an aeroplane; first, by means of an automatic device, such as gyroscope, and second, by such a disposition of the surfaces of the aeroplane that the machine has inherent stability. Very little success has been obtained from the first method, but the second is now very largely employed.

Questions relating to stability and controllability are intimately connected but in one sense they are distinct. Thus it is possible to have an unstable aeroplane which is readily controllable and very popular with pilots.

Stability may be considered under three heads: —

Longitudinal stability,
Lateral stability, and
Directional stability.

The first, longitudinal stability, is obtained by means of the tail plane, and the size of this for any particular type determines within limits the degree of stability. The fundamental point, however, is the position of the centre of gravity of the aeroplane relative to the main planes. If this is too far aft no tail plane can be found to give stability. The farther forward the centre of gravity, the smaller is the tail plane required.

The problems of lateral and directional stability are very closely connected, and must be considered together. Lateral stability is obtained by giving the main planes a dihedral angle, and directional stability is obtained by a proper regard to the dimensions and dispositions of the fins and rudders. The area of the fin and rudder required is a function of the dihedral angle.

The outbreak of war found us in a very favourable position with regard to the development of an inherently stable aeroplane. The importance of this feature from a military point of view had been fully realised, and special efforts had been made to produce a stable and at the same time controllable aeroplane. That these efforts were successful was largely due to the late E. T. Busk, of the Royal Aircraft Factory, as it was then called, and the B.E. 2c aeroplane, which embodied the results of his work, had been fully tested and demonstrated to possess complete adherent stability prior to the outbreak of war. Unfortunately, Mr. Busk was killed in a flying accident shortly after his experiments had been brought to a successful issue. However, his full scale research had been carried so far that the principles underlying the design of this machine could be applied to any other design of aeroplane. Subsequently nearly all machines were designed for inherent stability, except such types as were considered to be more suitable for their specific work if a certain degree of stability were sacrificed for very quick manœuvrability. An impression was prevalent, at any rate during the first two or three years of the war, that a stable aeroplane must necessarily be very heavy on its controls, and since quick manœuvrability was an essential for fighting scouts, the aim of designers, encouraged by fighting pilots, was to obtain the maximum controllability and quickness of handling, irrespective of stability.

It was gradually realised that this was a mistaken view, and that the comparatively poor manœuvrability of some of the earlier stable machines was due, not to the fact of these machines being stable, but to the particular design of the controlling surfaces. A very great amount of research into the conditions governing stability and controllability was carried out both from the theoretical and experimental standpoint, and thus revealed enough data to enable aeroplanes to be designed combining inherent stability with good manœuvrability, and as a result, the prejudice against stability in small fighting aeroplanes quickly disappeared.

A good example of the advantage of this is afforded by Captain Ball's wonderful return to our lines on his stable S.E. 5 machine after his controls had been almost completely shot away. The aeroplane practically flew itself back, and with only half of his normal elevator control he was able to make a safe landing on the aerodrome. Such a feat would have been out of the question on an unstable machine.

At the end of the war we were calling for aeroplanes with neutral stability for fighting work, i.e., aeroplanes which followed the pilot's mind and hand in whatever attitude they were put. For bombing and long-distance work stability is a very important asset, as it relieves the pilot of fatigue, and facilitates the maintenance of his course and his sighting for bomb dropping. The disadvantages of not putting a sufficient amount of study into these features are demonstrated by German practice. Although a few of their small aeroplanes were fairly manœuvrable, their larger ones did not compare favourably with our own when tested under the same conditions, and in the case of their very large bombing aeroplanes we had evidence that the pilot's difficulties on a long flight were very considerable, and it is probably not too much to say that the heavy proportion of German bombers which were crashed on returning from their raids was largely due to lack of stability and controllability.

Monoplane, Biplane or Triplane.—During the war all these types have been experimented with, and, in fact, have been built on a production scale, and it cannot be definitely stated that one type is more suitable than another without knowing the exact purpose for which the aeroplane is required.

Broadly, the comparative advantages of the three types are as follows: In comparison with the biplane, the monoplane is 5 per cent. more efficient as a weight carrier per square foot, and can be made to afford a better fighting view. On the other hand, it is weaker for the same weight of structure, and is less manœuvrable for equal total weight. Similarly the triplane, comparing it to the biplane, is 5 per cent. less efficient, but is more manœuvrable, and affords opportunities for a deeper and therefore stronger main gerder, which gives it an advantage for the larger sizes. Incidentally, it is also more difficult and expensive to produce. The balance between advantage and disadvantage therefore depends upon the particluar function required from an aeroplane, and also on the skill of the designer in overcoming the peculiar difficulties of his problem. But the general conclusion is that the monoplane is most suited for the very small aeroplane; the biplane for all general sizes, and probably the triplane for the very large sizes. Experience during the war in general bears this out, although there have been instances which might be taken as contradictory to this statement.

The importance of the successful use the Germans made of their Fokker monoplane should not be exaggerated, as the real reason for this success was the production in large numbers of a good single-seater with a rotary engine copied from the French Gnome, combined with the new synchronised guns, and a fresh method of attack. When we tested the aeroplane ourselves, and compared it with our own under similar conditions, its performance was in fact very little superior to the B.E. 2c, against which it was so effective.

Our designers, on the other hand, made a very successful triplane fighter with a similar sort of engine. The main objectives of the designer in this case were handiness and view ahead. Handiness was obtained by very small span, and view by placing the pilot so that his eye was in the line of the centre plane. However, as far as this country was concerned, the general decision was the selection of the biplane as the simplest and soundest type for all ordinary work.

Climb Requirements.—The most valuable quality in a war aeroplane and the one most difficult to supply is no doubt climb. Practically all other considerations are opposed to fast climb, such as high superficial loading, direct drive engines, high speed and long range. But the demand by pilots for a high rate of climb, both as a protection against anti-aircraft fire and to increase their fighting capacity was so great, that this quality had to be provided. The range of guns, or rather their power of accurate shooting at a height, increased in an astonishing degree during the war. In the early days, a height of 3,000 ft. was reasonably safe, and aeroplanes could do their work at that height. Then it was increased to 6,000 ft., 10,000 ft. and 15,000 ft. By the end of the war shooting even at 20,000 ft, was unpleasantly accurate. Whenever a new type of aeroplane appeared which could operate at an increased height, it was immune for a period, and could do its work almost unmolested, and in some cases without being perceived; but this period seldom lasted long, and sometimes even before the new type was appearing in sufficiently large numbers to count seriously, it was outranged.

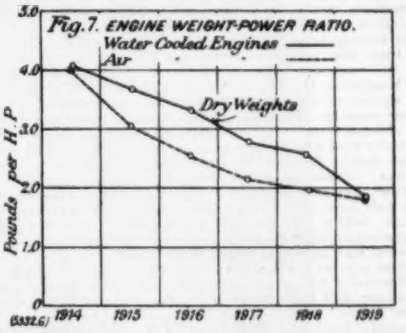
The same state of affairs applied to the height at which fighting took place, which gradually increased from year to year up to 20,000 ft. In order that the pilot could fight in a satisfactory manner he required a good rate of climb as well as the uppermost position. The difficulty of providing climb in an aeroplane during the first two years of the war was enhanced by the constant increase in the number of accessories required to enable the extra military functions to be carried out. These accessories added largely to the weight and also to the air resistance, and it was not until specially-designed aeroplanes appeared that the position became satisfactory.

Interaction of Engine and Aeroplane Design.—Progress in aeroplane was very much bound up with the progress in engine design; in fact, it can be broadly stated that during the whole of the war the aeroplane designers were waiting upon the engine designers, and as soon as any new engine was developed to a satisfactory point, it was but a short time before aeroplanes were in service, making the maximum use of such an engine, or at any rate a thoroughly effective use.

It is interesting to compare German practice with our own. The Germans realised at an early stage the necessity of large engines, and they concentrated their attention on the production of a first-class but simple type of motor. This had a straight row of six cylinders of an average weight per horse-power, neither excessively heavy nor particularly light. They standardised this type at a comparatively early date and consequently made early advances in production and reliability.

Our policy was by no means so definite, and our engine designers worked on a number of different types; air-cooled rotary, radial, and in V, water-cooled, eight-cylinder, twelve-cylinders in V and six cylinders in line. At no time did we rigidly standardise a single type. In consequence, we had far bigger difficulties in production, and on the whole our motors were not so reliable. Ultimately, however, we progressed much further than the Germans, both in the power of the engine, and in the reduction of weight per horse-power.

The reduction of weight of the aeroplane per horse-power can be obtained in either of two ways: (1) By having a very powerful engine of average weight pe



horse-power, so powerful that the weight of the pilot and his military gear is relatively an unimportant factor; or (2) by having an engine of very light weight per horse-power. This point is best illustrated by a short analysis in weight per horse-power, comparing two aeroplanes which are both single-seated fighters, and of the same pounds per horse-power.

Large Aeroplane.	Lb./H.P.
300-h.p. engine weight	3½
2 hours fuel, oil and tanks	1½
Pilot and gear	1
Aeroplane structure weight	3
	9

Total weight, 2,700 lb.

Small Aeroplane.	Lb./H.P.
200-h.p. engine weight	2½
Fuel, oil and tanks	1½
Pilot and Gear	2
Aeroplane structure weight	3
	9

Total weight, 1,800 lb.

The first type has a large water-cooled engine, is economical in fuel, and by reason of the size of the engine, the pilot and his gear account for only a small proportion of the total weight; whereas on the small aeroplane the engine is a light weight air-cooled engine of heavier consumption, and the weight of pilot, &c., is a much larger proportion of the whole weight.

The two aeroplanes would practically give the same performance, but the smaller probably would be the better fighter because of its greater manœuvrability. There are many other factors to take into account, such as reliability, pilot's view, ease of manufacture, &c., all of which must be considered before coming to a decision as to which is the better type.

Generally speaking the tendency during the war was towards the heavier aeroplane, although there were two periods when the light-weight engine reversed this. One was when the 80 Le Rhone Sopwith Pup supplanted the 140 R.A.F. B.E. 12, and the two 100-h.p. pushers D.H. 2 and F.E. 8; the other was when the small air-cooled Wash engine was competing with the 275 water-cooled Rolls-Royce Falcon.

(To be continued.)

INTER-ALLIED COLONIAL EXHIBITION AT PARIS.—At the sitting of the French Chamber of Deputies on June 12 a Bill was passed providing for the holding of an Inter-Allied Colonial Exhibition at Paris in the year 1924. In connection with this exhibition a building is to be erected for a permanent Colonial Museum.

WOMEN'S WORK IN ENGINEERING AND SHIPBUILDING DURING THE WAR.*

By the Hon. Lady PARSONS, Hon. Fellow.

Introduction.—The entry of women into the engineering trades is not a fact dating only from the war, as is often supposed, although the immense influx of women took place in 1915. Already in 1840 cheap female labour in the metal trades was becoming a serious complication, and the numbers of women were increasing steadily. About the year 1870, the brass workers, the nut and bolt makers, the chain and nailmakers, and the makers of all sorts of small metal goods, protested loudly against the invasion of their trades by women. The men's unions, too, stood out against any organisation of women, because, they argued, to organise was to recognise, those outrageous women who turn at the lathe and file at the vice. Mrs. Drake, in her excellent book, tells us that a chain maker wrote to complain that when he himself is exhausted with labour, his daughter can still go on.

About 1900 women began to pour into the electrical and other new and progressive trades, such as the cycle and motor trades; but the chief centres of women's employment remained round Birmingham and Coventry. The displacement of men by women generally followed the introduction of new automatic machines. The division and simplification of processes began to take marked effect on the numbers of skilled men. The men's unions complained that the employment of women was a chief cause of their unemployment, because fewer skilled men were required, and this encouraged the employment of a less skilled and less robust type of worker.

Suddenly the war brought an immense demand for women's labour. When the shortage of munitions became known it was evident that unless the supply of munitions could be enormously increased, our armies would certainly be defeated in the field. The works had already been depleted of hundreds and thousands of their best men, and there was no supply of labour to fall back upon, except women. The then Minister of Munitions, Mr. Lloyd George, made a stirring appeal to women to come out of their homes and help to save their country; but women were already clamouring to be allowed to work in the shops, and well it was for the country that women responded so quickly to the call for their help. Women of every class poured into the works; dressmakers, milliners, teachers, musicians, artists, domestic servants—those who had worked hard all their lives, and those who had never done a stroke of work before. Employers accomplished wonders of organisation, in order to accommodate their new workers; hostels and canteens sprang with mushroom growth.

The women put up pluckily with all the discomforts incidental to a huge new enterprise set up as an emergency measure, and the discomforts were often very real and very severe. Canteens were new, and necessarily experimental; food was often very insufficient, and in some localities there was no way of supplementing it; workers had often long distances to travel. The cold at night was sometimes intense, and with the poor food, the cold and the unaccustomed nature of the work, some suffered intensely.

Then it must not be forgotten that in a certain class of factory the danger of explosions was constantly present, and unhappily resulted many times in terrible loss of life.

Then there were the air raids, sufficiently alarming to many people leading their ordinary lives in their well-screened houses; but when hundreds of workers were gathered within the brightly lighted shops, and all the conditions were unusual and exciting, a highly nervous mentality was produced. Great judgment and careful handling were required on the part of those in charge of the workers, in order to repress and allay any symptoms of panic; but the same spirit of enthusiasm was in the girls as was in the splendid young men, who, in the early days of the war, flocked in thousands to the recruiting offices and put up cheerfully with every kind of rough accommodation only to have the honour of serving their country.

I will not go into a detailed account here of the semi-skilled work accomplished by women, nor recite again the oft-told tale of all the varieties of shot, shell, hand grenades and every implement of destruction made by the women's hands. Ninety per cent. of the workers in munitions were women in 1918. Their work was generously recognised—their endurance called out sometimes extravagant praise on the part of the Press and the public generally; but I wish to emphasise some of the more skilled work that women learned to do, because there is a strong tendency among engineers to consider that women are only capable of doing repetition work on fool-proof machines. There is no doubt that many women developed great mechanical skill and a real love of their work.

Skilled Work.—Quite a large number of girls were able to set and grind their own tools, and a small proportion could set up their jobs from drawings. They could mill all the parts of the breech mechanism of howitzers, screwing the internal thread for the breech block, milling the interrupted screw and screwing the cone that fits into the breech block; milling firing pins and all the parts of gun sights; in each case setting up their own work. In a firm repairing guns two girls dealt with guns varying from the 13-in. naval gun, weighing 50 tons, to the 6-lb. tank gun. They could design repairs to guns and mechanism and calculate the factor of safety of a damaged gun by logarithm and slide rule. They were designing suitable repairs, making the working drawings and carrying out the work, and if necessary making the special tools to do it. Others were hand-lapping bores of guns clearing the rifling grooves and making impressions of the bores of guns in gutta percha. The girls who did this work were taught in one day to work a 12¼-in. lathe. This included setting up the work, dividing on change wheels and cutting an internal-screw thread.

In a still surviving factory staffed by women, they are employed on all the parts of the engine of a motor tractor. They are cutting out the crankshafts from the solid forging, using the drilling and slotting machines, and they are making all the tools, jigs and fixtures required for the work of the factory, setting up their work, and designing some of the tools. This factory is generously continued by the employers, in order to give the women, who worked so well during the war, the opportunity to continue their training in the hope of employment as soon as trade conditions are more settled.

The women acetylene welders established a good reputation early in the war, and they have been steadily working on jobs interchangeable with men. In a firm specialising on lathes women are machining all the parts of a 6¼-in. and an 8-in. lathe; they are doing the bench work, and assembling and fitting. Other girls have been successfully employed in designing and making machine tools. Another in one of the technical workshops could make every article that came into the shop from beginning to end, and she could mill gauges true to 0·00003 in.

Experiments.—In metallurgy some useful experiments were made in the causes for failure of metal and alloys and the methods of producing reliable metals. In an experiment tank models of the hulls of ships and seaplanes were tested with a view to improving their form. In electro-technics tests were made of Admiralty instruments, ammeters, and volt-meters, resistance boxes and standards, the practical part of a research on the heating of buried cables, and the preparation of plans for the installation of a new generating set.

Optics.—In optics, research work has been done in the comparison and improvement of various methods of testing. Tests have been made of the optical properties of rough samples of glass, of finished lenses and prisms, and also in ceramics for the crucibles in which the molten glass is contained. In the cutting and polishing of optical glass almost every process is done by women. First the thick squares of glass are cut out by a revolving disc whose edge is faced with minute particles of diamond; next, by hand tools the women roughly round the square, then grind to concave or convex surface, and finally polish by numerous careful processes. The accuracy of the lenses is judged by the colour bands, a perfect band of colour meaning an accurate surface and a broken ring of colour or supplementary rings meaning that the lens must be further polished. The making of the entire binocular is women's work, and an industry built up since the war. First the sand cores are made, then comes the rough ending of the casts. The vulcanising, the colouring, the assembing and fitting are all women's work; and they have also learned how to test the accuracy of the finished binocular. On mirrors, women have been working with great success. They back the mirrors and do a great deal of the polishing and the fitting. We are all familiar with the beautiful beams of light travelling over the sky in the search for Zeppelin and aircraft. Their beauty stirred the imagination of both painters and artists. Here on the Tyne we may feel great pride in the mirrors and searchlights, as most of us know that Tyneside girls polished the mirrors and so added to the brilliancy of the searchlights.

Ministry of Munitions Exhibitions.—In the year 1916 exhibitions of women's work in engineering were held under the direction of the Ministry of Munitions, and in several large industrial centres. The immense range of the work they were shown to be doing must have come as a great surprise to many employers. The exhibits included aeroplane engines, fittings and woodwork, parts of internal-combustion machines, magnetos, part of the breech mechanism of guns and their sights, tool-room work, gauge making, light body armour, face visors and masks of fine steel links, and in addition, all the ordinary munition work, such as shot, shell, cartridges, fuses, grenades and bombs.

The exhibitions proved conclusively that women are able to work on almost every known operation in engineering, from the most highly-skilled precision work, measured to micrometer, down to the rougher sort of labouring jobs. To enumerate all the varieties of work intervening between these two extremes would be to make a catalogue of every process in engineering.

If any further confirmation were needed to establish the importance of the work achieved by women in England it was supplied in a novel and noteworthy form. Engineering firms were invited to apply for the services of skilled women operators, who would be sent out to demonstrate the amount of output that can be produced in certain classes of work. It was a remarkable admission that women with their short experience should be deemed capable of assisting employers in the difficult task of speeding-up production in their own special profession.

Reasons of Success.—In considering the causes that led to the work of women producing such good results, one does not wish to claim any remarkable ability or outstanding qualities. The success was due to the sensible training given to women, and they had the advantage of receiving a short intensive training in the technical schools set up by the Ministry of Munitions and in private firms. They had the great privilege of being taught their work by skilled men who ungrudgingly gave their experience in teaching the women and without whose assistance it would have been impossible to train them. These technical schools proved that a short intensive training will turn out a sufficiency of useful workers, and that an intelligent girl can learn almost any mechanical process in a few weeks, a prolonged apprenticeship not being necessary, at any rate for women whose working years will generally be much shorter than those of men.

Now, boys and men are benefiting from the methods that proved so successful with women. Men and boys must not forget that women prepared the way for this sort of intensive training, and that their entry into work also brought about the improved conditions in the works the hostels and canteens continue though the women for whom they were originally planned have gone, the immense and beneficial changes, due to their employment, have become an established fact in the works.

Great hopes were entertained by many women that a new profession was open to them, where they could earn good wages and where they would have some scope for their skill and intelligence. But with the signing of the armistice all such pleasant hopes were destroyed, the training schools were closed to women, the trade unions reminded employers of the Government pledge to restore trade union rules, and within a few weeks the demobilisation of women dilutees was general.

The Trade Unions.—About 1,500,000 women had received a certain amount of training in schools that has cost the country over 30,000,000*l.* All these prospective wealth producers are scrapped; the country is much the poorer. The engineering industry is again barred to women by an agreement made between the Treasury and the trade unions. Although 90 per cent. of the workers on munitions were women, yet in the agreement of February, 1916, between the Treasury and the trade unions, no women were sitting on the conferences that preceded the agreement. Consequently the women's point of view was never raised.

The Labour Party, while demanding full political equality for women and the right to sit in the House of Lords and to practice at the Bar and as solicitors, will not grant to women industrial equality by permitting them to work on the same jobs as men, to have adequate representation on committees, or to enter the higher ranks of those industries which the war has shown they are perfectly fitted to work.

It has been a strange perversion of women's sphere—to make them work at producing the implements of war and destruction and to deny them the privilege of fashioning the munitions of peace. The women who worked so hard to win the freedom of the world may not have freedom at home to engage in an industry where the wages are promising. It is fully acknowledged that men will not go back to pre-war conditions; they must have shorter hours, more leisure, more wages. But as for women, they are merely told to go back to what they were doing before, regardless of the fact that, like men, they have now a higher standard of life, that they also wish to have their economic independence, and freedom to make their way without any artificial restrictions.

APPENDIX.

The number of women employed in National Shell Factories in April, 1918, was 12,939. Of these there were:—

Forewomen	62
Tool-room	127
Charge hands	245
Machine operators	7,676
Labourers	1,315
Viewers	1,193

The total number of women in National Projectile Factories in April, 1918, was 20,667. Of this number there were:—

Forewomen	68
Charge hands	432
Machine operators	9,418
Labourers	2,858
Viewers	2,740

The above figures are obtained from the Report of the War Cabinet Committee on Women in Industry.

* Paper read at the Victory Meeting of the North-East Coast Institution of Engineers and Shipbuilders, at Newcastle, July 9, 1919.

THE USE OF PULVERISED COAL.

*Use of Pulverised Coal, with Special Reference to its Application in Metallurgy.**

By L. C. HARVEY (London).

A REPORT on the whole subject of the preparation and application of pulverised coal has recently been submitted by the author to the Director of Fuel Research. This report embodies the results of investigations carried out in America, and contains a general *résumé* of the advantages claimed for the use of solid carbonaceous fuels in pulverised form. The report deals chiefly with the application of pulverised fuel to steam raising, the generation of motive power, and as a source of heat in metallurgical works. The various types of fuels suitable for use in pulverised form are considered, and installations which have been at work for some years in America are described, and particulars are given of the capital cost of the plants, of the working costs and methods of operations.

The following paper is intended to form a supplement to the information contained in the above-mentioned publication, which is referred to hereafter as the "Report." It cannot be denied that remarkable progress in the use of coal in powdered form has been made in America during the past five or six years. The reason that this method has not received in this country the attention which it merits is undoubtedly due to the war and to the difficulties and delays attendant upon the introduction of new systems, radically affecting works operations.

In view of the many and varied valuable by-products

* Paper read before the Iron and Steel Institute on Thursday, May 8, 1919.

derivable from coal which can only be reclaimed by means of distillation, it might be suggested on first consideration that any progress in the direction of economising fuel resources should take the form of preventing consumption of any coal in the raw state. Whenever it becomes an accomplished fact that all industries requiring power or heat can be supplied with cheap electric energy or gas from the super-power stations now proposed, where the coal used will be subjected to distillation, it will be time enough to prohibit the direct combustion of coal. Possibly pulverised fuel will itself play an important part in promoting the universal distillation of coal by providing a ready means for the disposal of the resulting by-product coke. Provided that 12 to 15 per cent. of volatile matter is left in the coke, such fuel can be efficiently burnt in pulverised form.

In the meantime, however, the fact that 12,000,000 tons of coal per annum are pulverised in America affords sufficient evidence of the immediate economy which might be secured by the use of powdered fuel, and what applies to America will apply also, and in greater measure, to this country.

With every increase in rate of wages, prices for materials, fuel, railway transportation, shipping freights and cost of living will be increased. Water-borne fuel such as oil, which now stands at a prohibitive price, is not likely to become extensively used in England; we must therefore use the coal, lignite, or peat deposits that we have ready at hand, and to far better advantage than we have done in the past.

A 6-hours' day at the mines, and a 30 per cent. increase in wages over war rates are estimated to cost the community some 45,000,000*l.* per annum, and will probably represent an all-round rise of at least 5*s.* per ton in the price of coal for industrial purposes. The wages of transport workers, railway employees—in fact, the wages of all classes—are bound to rise in sympathy, so that coal may cost three and probably four times pre-war prices, and the higher the price of coal the more necessary it becomes to cut down consumption.

Although it is rightly claimed for pulverised fuel that any grade of coal can be used in this manner, it is naturally on the high-priced fuels that the savings effected become of greatest monetary value.

By installing pulverised coal systems the whole of the coal supply is concentrated at one or more central milling stations. All truck lines, aidings, engines, truck lifts, &c., and practically all labour for coal transport throughout the works are dispensed with. A view of the interior of a typical coal mill plant is shown on this page, Fig. A.

It can be taken as an outside figure that the drying, grinding, and transportation of 100 tons of pulverised coal will require the attention of not more than four men per shift per 24 hours; or, say, 12 men on 8-hour shifts, or 24 men on 6-hour shifts. The usual American allowance for this output is three men per shift per 24 hours; two men in the mill house, and one man on the transport line. At the furnaces it is often possible to do entirely without firemen, as the fuel is applied in the same manner as oil or gas, and the temperature within the furnace is easily regulated by the men carrying out the actual metallurgical operations.

Another important economy consequent upon the use of pulverised coal is the reduction in metal loss or scaling. In one instance in America a total amount of 3·68 tons of steel was saved in this manner per day on a reheating furnace having an output of 168 tons of billets (for rolling), or a saving of over 2 per cent. in actual metal as compared with hand-firing. This was chiefly due to the small amount of excess air used with powdered coal. Also, owing to the ease with which a reducing atmosphere can be maintained, oxidation in annealing furnaces is almost entirely overcome, and the life of annealing boxes is in consequence twice as long as with hand or gas-firing.

In summing up these general advantages, such as saving in coal, saving in works equipment costs, freeing railway space for other purposes, removal of causes for accidents, considerably reduced labour costs for fuel handling and burning, reduced loss of metal often with a considerably increased output of furnace plant and steam boilers, increased life of refractory brickwork (excepting only open-hearth furnaces), increased life to annealing boxes, it must be admitted that there are great possibilities attaching to this system of burning solid fuels. As a means of using up accumulations of low grade and high ash fuels, such as mine tips, and the exploitation of lignite, peat and other carbonaceous deposits, pulverisation offers a ready solution.

The accompanying table from the Final Report of the Coal Conservation Committee shows a subdivision of coal consumption for home purposes (see Table I), and upon the figures given an estimate has been made as to the possible total quantity of fuel that might be used in pulverised form.

That this table is necessarily based upon wide assumptions is admitted, but it will perhaps indicate the range of possibilities in this direction, and suggest a relation between capital expenditure and overall operating costs for applying and burning powdered coal in the quantities stated.

In his recent address to the Society of British Gas Industries, Sir Robert Hadfield gives very valuable information as to fuel statistics, heating values and costs, and furnace efficiencies for the various methods of heating. By kind permission the accompanying Table II has been reproduced from Sir Robert Hadfield's address, and to this has been added an estimate of the quantity and cost of pulverised coal required for melting 1 ton of steel.

In order to arrive at the relative values for pulverised coal, a fuel containing 14,000 British thermal units (the basis taken for the producer-gas figures) has been assumed, and with such a fuel value a reduction of 8 to 5 can be made as against producer gas for medium size open-hearth plants.

A fuel economy bearing this ratio was effected in a steelworks in America when melting steel with Illinois coal of 10,000 British thermal units, and on this basis the quantity of coal required to melt 1 ton of steel, given in Sir Robert Hadfield's table, can be reduced to 0·2 of a ton when powdered coal is used.

When considering the use of electricity for steel melting, the figures for power or heat losses given by Sir Robert Hadfield show that we may start with a coal having a value of 14,000 British thermal units, of which 4,957 British thermal units are used in the furnace, the balance being dissipated in the following order :—

Raw coal value = 14,000 B.t.u.

	Per Cent.	B.t.u. used.
Overall efficiency of boilers ...	75 =	10,600
Turbine efficiency	80 =	8,480
Generator efficiency	72 =	7,801
Line efficiency	99 =	7,722
Transformer efficiency ...	98 =	7,365
Conductor efficiency	99 =	7,291
Furnace efficiency (taken from Table II)	68 =	4,957

4,957 British thermal units is, roughly, 35·4 per cent. of the British thermal unit value of the coal used in the generation of electric power supplied to the furnace, and cost per ton melted is 30*s.* 11*d.* On the other hand, powdered coal will show the following overall heat value loss :—

Raw coal = 14,000 B.t.u.

Drying process 2 per cent. coal value = 13,720 B.t.u.

Power for crushers, elevators, dryers, mill conveyors, and air-fans at furnaces absorb about 30 kilowatt-hours per ton of fuel burned; that is, 0·04 lb. of coal is used for these purposes per. lb. of fuel burned. This reduces the 13,720 B.t.u. by 560 B.t.u. = 13,160 B.t.u.

Allowing for furnace efficiency of 20·2 per cent. (taken from Table II) when burning powdered coal, the heat value of coal actually used in the furnace becomes 2,444 British thermal units, or 17·4 per cent. of the original British thermal units value of the coal. Cost per ton of steel melted = 3*s.* 11*d.*

Producer-Gas Firing.

Raw coal, 14,000 B.t.u. at 13·5 per cent. overall efficiency = 1,890 B.t.u. used.

Cost per ton of steel melted = 5*s.* 8*d.*

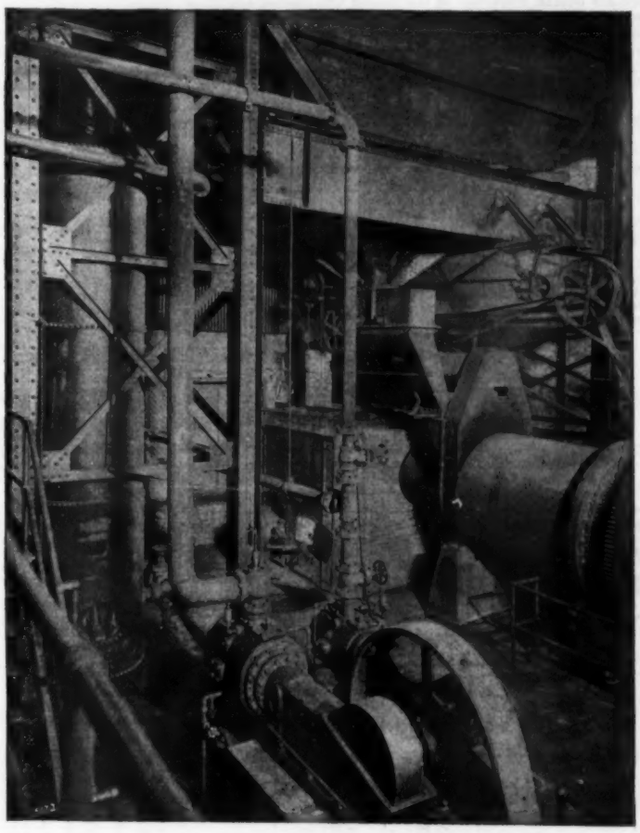
It must be remembered that there is no possibility of working waste heat boilers in conjunction with electric melting furnaces, whereas with powdered coal and producer gas possibly 50 per cent. of the heat passing out of the regenerators can be used for raising steam.

This being so, the heat values for the three systems then bear the relation tabulated in the statement below.

In the metallurgical world it will be chiefly in comparison with producer-gas practice that powdered coal will be considered. In certain cases the advantages of the one will outweigh those of the other.

Each system has its rightful sphere of usefulness, and each has its faults and difficulties.

In the new types of modern mechanically fed gas-producers, such as those of the Morgan Construction



Interior view of typical pulverized coal mill house showing crushed coal storage bin, dryer and Quigley blowing tanks.

FIG. A.

Company of Worcester, Mass., in which ash removal ploughs are employed in addition to mechanical feed gear, it is stated that one man can tend a battery of six 10-ft. producers. This company claims for their most recent 10-ft. producers a duty equal to 3,000 lb. of coal gasified per hour, giving gas of 178 British thermal units as against 1,600 lb. to 1,700 lb. of the same quality

—	Heat Value of Raw Coal.	Ultimate Value of Heat Used.	B.t.u.'s Used, per Cent.
	B.t.u.		
1. Powdered coal furnace..	14,000	7,708	55·0
2. Producer gas furnace ..	14,000	6,731*	48·0
3. Electric melting furnace	14,000	4,957	35·4

* This allows for a producer efficiency of 80 per cent., and a furnace efficiency as for powdered coal, 20·2 per cent., which is a liberal allowance for gas firing.

of coal gasified in most of the well-known mechanical producers, making gas of about 145 British thermal units per cubic foot. This means that one man on an 8-hour shift will tend a "Morgan" producer plant handling 144,000 lb. of coal and at 75 per cent. overall heat value efficiency at the furnace a coal equivalent of 138,000 lb. of coal burned in the furnaces.

In a coal pulverising mill a shift of three men will be required to operate the dryer, mills and conveying system for an output of 8 tons per hour, or 143,360 lb. per 8-hour shift or 47,786 lb. of coal per man, of which 95 per cent. will be received at the furnace or 45,316 lb. of coal burned in the furnace. Normal practice with ordinary mechanically fed producers is said to be only one-fourth the amount of coal handled per man as com-

pared with the latest types of Morgan producers. If this is so, the coal handled per man per shift will be 35,840 lb. per 8-hour shift on ordinary mechanically fed producers; for hand-fired producers but 10,000 lb. or so.

As against hand-fired producers pulverised coal systems therefore show a very greatly increased tonnage handled per unit of labour, and as against normal mechanically fed producers an increase of 25 per cent. In comparison with hand-fired and hand-poked producers, moreover, at least four times the heat equivalent of coal can be delivered to the furnaces per single operator per shift.

A comparison between furnace efficiencies for powdered coal, oil and producer-gas firing has been made by Mr. C. F. Herrington.*

No allowance for overall efficiency of the plants was made in these calculations, and if one accepts an overall

Specific heat of wrought iron = 0·113 (Kent).
Temperature rise from 1400 deg. to 2500 deg. = 1100 deg. F.
Furnace charged with 3,800 lb. iron.
To raise this iron to that temperature required 14,000 cubic feet of gas.
0·113 × 1100 = 124 B.t.u.
3800 × 124 = 471,200 B.t.u. output.
14,000 × 300 = 4,200,000 B.t.u. input.

$$\text{Efficiency} = \frac{471{,}200 \times 100}{4{,}200{,}000} = 11{\cdot}2 \text{ per cent.};$$

or allowing 75 per cent. overall producer efficiency $= \frac{471{,}200 \times 100}{5{,}600{,}000} = 8{\cdot}4$ per cent.

No doubt the outstanding questions of particular interest are those concerning capital cost for pulverising plant of various capacities, the overall operating costs

use powdered coal in the one department where initial trials are to be carried out, but to extend the application to other shops in course of time. In such cases it will be advisable to instal the complete mill-house plant, but in order to use powdered coal in small quantities it may often be better policy to purchase self-contained pulverising units such as the "Aero" machine.

It will be seen that capital outlay and running costs for small complete mill-house plants may become out of proportion to the benefits to be realised.

In the table of operating expenses (Table IV on page 62) it has been assumed that for the whole range of capacities even below 20 tons per day complete mill-house equipments will be preferred.

Table V. shows capital costs for small self-contained units of the "Aero" type, and overall running costs on the same basis of calculation as for those accepted for the larger installations. It does not necessarily

TABLE I.

—	Actual Consumption, 1903.	Proportion of Total Amount for which Pulverised Coal might be Used.	See Note.	Raw Coal. Present Consumption Equivalent.	All-round Reduction by Use of Pulverised Coal.	Net Saving of Coal.	Raw Coal. Reduced Consumption in Pulverised Form.	Cost Figures for Powdered Coal Plant, Conveyor System, Burners, &c.
	tons.			tons.	per cent.	tons.	tons.	
Railways	15,000,000	40–50 per cent., not feasible at present	A	6,500,000	40	2,400,000	4,100,000	On a basis of 25,000*l.* for mill-house building and machinery, transport, equipment, and burning apparatus for 100 tons per 24 hours, the cost of pulverised coal plant for 33,000,000 tons per annum would be (for 300 working days) approximately 27,500,000*l.*
Coasting steamers	2,000,000	,, ,,	B	—	—	—	—	
Factories	53,000,000	Say 30 per cent.	C	15,900,000	20	3,180,000	12,720,000	
Mines	18,000,000	,, 50 ,,	D	9,000,000	30	2,700,000	6,300,000	Interest (at 6 per cent.). Depreciation (at 10 per cent.) on investment = 4,400,000*l.*
Iron and steel industries	28,000,000	,, 30 ,,	E	8,400,000	20	1,680,000	6,720,000	
Other metals and minerals	1,000,000	,, 40 ,,	F	400,000	20	80,000	320,000	Maintenance of mill-house machinery and all equipment on American basis 5 cents per ton in mill, and 5 cents per ton on equipment = 687,500*l.*
Brickworks, potteries, glass-works and chemical works	5,000,000	,, 25 ,,	G	1,250,000	30	375,000	875,000	
Gas works	15,000,000	—	—	—	—	—	—	Labour at 9 men per day on 3 shifts for 100 tons per 24 hours, at 3*l.* per week per man and payment on 52 weeks = 1,544,400*l.*
Domestic	32,000,000	,, 10 per cent.	H	3,200,000	50	1,600,000	1,600,000	
		Totals		44,650,000			32,635,000	Dryer fuel and dusting loss at 5 per cent. on 33,000,000 tons of coal at 30*s.* per ton = 2,475,000*l.*
		Total annual saving in coal by use in pulverised form				£ 11,615,000		Power for milling, conveying and burning at 30 kw.-hours per ton overall cost of electric power at ¼*d.* per unit = 2,062,500*l.*
		Total value of coal saving at 30*s.* per ton				17,422,500		Total cost for preparing and burning coal in pulverised form = 11,100,000*l.* (say 11,000,000*l.*).
		Cost of pulverising and burning				11,000,000		Overall cost per ton of coal burned in powdered form = 6*s.* 8*d.*
		Net annual saving*				6,422,500		
		Cost of plant and equipment				27,500,000		

* Exclusive economy effected in labour costs, loss of metal, &c., &c.

A. Making allowance for existing electrified lines.
B. Pulverised coal may eventually be used for coasting steamers, either bunkered in powdered form, pulverised on board, or used in colloidal state with crude oil.
C. Assuming that 75 per cent. of the estimated total consumption is used for steam-raising and heating processes.
D. Assuming that the estimated total consumption is for coal used for power and haulage and does not include coal distributed to miners and used for domestic purposes. Usage of coal for heating and subsidiary purposes at the mines may account for a considerable quantity of this total coal used.
E. Coal in pulverised form could undoubtedly be applied very extensively in the iron and steel industries, leaving out of account blast furnaces and gas-fired open-hearth melting furnaces.
F. For copper melting powdered coal has replaced other fuels in the States. It could also be used to advantage in the melting and annealing of brass and other alloys.
G. Powdered coal is very suitable for firing kilns and for glass-melting, especially where hand-fired coal or oil-fuel firing are now employed.
H. This would only apply to central heating systems for offices, hotels and institutions, for which purposes pulverised coal would be delivered daily by a central supply company.

TABLE II.—MELTING 1 TON OF STEEL.

—	Amount of Fuel or Energy Consumed.	B.t.u. in Fuel Used.	Cost of Fuel.	Fuel. Total Cost.	Heat Efficiency.	Lost Heat.	Tons of Raw Coal Used.
Crucible Melting.	tons.			*s.* *d.*	per cent.	per cent.	
Coke	2·50	73,000,000	47*s.*	117 6	1·4	98·6	3·75
Open-hearth Melting.							
Producer gas	0·30	9,400,000	19*s.*	5 8	13·5	86·5	0·3
Pulverised coal	0·20	6,272,000	19*s.*	3 10	20·2	79·8	0·2
Correcting for coal consumed for preparing and burning at 18 lb. coal per ton steel	0·208	6,510,000	19*s.*	3 11	19·5	80·5	0·208
Electric melting	515 units	1,780,000*	0·72*d.*	30 11	68·0	32·0	0·66

* 20,000,000 in coal at power station, 0·66 ton of coal.

loss of 5 per cent. in coal for powdered fuel systems and 25 per cent. loss for producer-gas practice, then Mr. Herrington's figures for the net overall efficiencies for the three systems bear the following relation as regards actual fuel efficiency :—

Powdered Coal (furnace using preheated air for combustion).
Furnace coal at 60 deg. F.
Steel and furnace heated to 2200 deg. F.
Rise in temperature, 2140 deg. F.
By test, 6·29 lb. of steel heated per lb. of coal burned.
Specific heat of steel, 0·117.
0·117 × 2140 = 250 B.t.u. per lb. of steel.
250 B.t.u. × 6·29 = 1,572 B.t.u. output.
1 lb. of coal = 14,000 B.t.u. input.

$$\text{Efficiency} = \frac{1572 \times 100}{14{,}000} = 11{\cdot}3 \text{ per cent.; or}$$

allowing 95 per cent. overall fuel efficiency $= \frac{1572 \times 100}{14{,}716} = 10{\cdot}7$ per cent.

Fuel Oil (same furnace with same rise in temperature and the same charge of work).
Heated 8·68 lb. of steel per lb. of oil.
1 lb. of oil = 19,400 B.t.u. input.
250 B.t.u. × 8·68 = 2170 B.t.u. output.

$$\text{Efficiency} = \frac{2170 \times 100}{19{,}400} = 11{\cdot}3 \text{ per cent.}$$

Water Gas (furnace using preheated air for combustion).
1 cubic foot of gas = 300 B.t.u.

* *Engineering News*, December 10, 1914.

for running these plants and attendant conveying and burning expense, also the relation that such figures bear to the price of coal. The author has endeavoured to set out these various costs in concise form both in tables and in curves, but additional allowance must be made for branch conveying systems, coal bins and burner gear at furnaces, boilers, &c.

Such additional cost may be taken at from 30 per cent. to 50 per cent. for normal works equipment, but may reach 100 per cent. on the cost of mill-house plant when furnaces are small and numerous, or scattered over a large area.

It is of little use to consider estimates as to mill-house cost wherein figures relating to capital outlay or running costs have been cut down to the lowest limits, for these minimum costs are seldom experienced in practice. Ample allowance has therefore been made in each instance to cover all reasonable charges at present-day high prices for material, machinery, buildings, &c., and sufficient allowance has been made for maintenance, interest, depreciation and labour.

In addition to the bare complement of drying and crushing plant necessary for the daily capacities given, a series of columns have been added to cover stand-by plant. The provision of the latter slightly increases the overall running costs, due to interest and depreciation charges on idle machinery.

Table III shows the number and sizes of dryers and pulverisers required for 5 tons to 1,000 tons of powdered coal per 24 hours and for complete mill-house equipments.

Unless extensions in the direction of additional furnace or boiler plant are contemplated, it will not be always sound practice to instal a complete mill equipment for a daily output below, say, 20 tons. On the other hand, it may often be the intention not only to

TABLE III.—*Mill-House Dryer and Pulveriser Mill Equipment.*

Daily Output in Tons.	Output per Hour in Tons.	No. and Size of Mills. Running Plant.	No. and Size of Mills. Stand-by Plant.	No. and Size of Dryers. Running Plant.	No. and Size of Dryers. Stand-by Plant.	No. of Men.	No. and Duration of Shifts.	Labour, Hours per Day.
		in.	in.	tons.	tons.		hours	
5	1–2	1–24	1–24	1–4	None	2	2–8	32
10	1–2	1–33	—	1–4	None	2	1–8	16
15	1–2	1–33	—	1–4	None	2	1–8	16
20	1–2	1–33	1–33	1–4	None	2	2–8	32
30	1–2	1–33	1–33	1–4	None	2	2–8	32
40	1–2	1–33	1–33	1–4	None	2	3–8	48
50	4	1–42	1–42	1–4	None	2	2–8	32
60	4	1–42	1–42	1–4	None	2	2–8	32
70	4	1–42	1–42	1–4	None	2	2–8	32
80	4	1–42	1–42	1–4	None	2	3–8	48
90	4	1–42	1–42	1–4	None	2	3–8	48
100	6	3–33	1–33	1–8	None	3	2–8	48
150	8	2–42	1–42	1–8	1–8	2	3–8	48
200	12	3–42	1–42	1–10	1–10	3	2–8	48
250	12	3–42	1–42	1–14	1–14	3	3–8	72
300	16	4–42	1–42	1–14	1–14	3	3–8	72
350	16	4–42	1–42	1–14	1–14	3	3–8	72
400	20	5–42	1–42	2–10	1–10	4	3–8	96
450	20	5–42	1–42	2–10	1–10	4	3–8	96
500	24	6–42	1–42	2–14	1–14	5	3–8	120
550	24	6–42	1–42	2–14	1–14	5	3–8	120
600	28	7–42	2–42	2–14	1–14	6	3–8	144
650	28	7–42	2–42	2–14	1–14	6	3–8	144
700	32	8–42	2–42	2–14	1–14	6	3–8	144
750	36	9–42	2–42	4–10	1–10	7	3–8	168
800	40	10–42	3–42	4–10	1–10	8	3–8	192
850	40	10–42	3–42	6–10	1–10	8	3–8	192
900	40	5–57	1–57	4–14	1–14	6	3–8	144
950	44	6–57	1–57	4–14	1–14	6	3–8	144
1,000	48	6–57	1–57	4–14	1–14	6	3–8	144

follow that this course is recommended, for under certain conditions the small self-contained units would be quite unsuitable. The difference between the cost of the small unit and that of complete mill-house equipment appears attractive, but the latter affords flexibility of supply, whereas a separate Aero unit must be installed for each furnace or kiln.

Table IV contains figures for labour rated at £3 per week per man, power costs at ¼*d.* per unit, and ample allowance for power has been included. As a rule it is considered sufficient to allow for power at the rate of 20 kw.-hours per ton of coal ground, delivered and burned, but in order to make sure that all contingencies and power requirements for different systems are covered as far as possible 30 kw.-hours have been allowed per

ton of coal. Repairs and maintenance costs have been based upon American figures, *i.e.*, 5 cents per ton in the mill and 5 cents per ton on conveyor and burner apparatus. Interest and depreciation has been taken at 16 per cent. on capital charges. The total costs for the various daily capacities can therefore be taken as representing reliable if not outside figures.

Screw conveyors to deliver the coal 300 ft. from the mill house have been allowed for in the cost of plant.

All the above tabulated figures are incorporated in the curves shown in Fig. 1. The initial and rapid rise in cost of "bare output" and "stand-by" installations for complete mill-house equipments will be noticed, and even more marked than these features are the excessive costs for operation on the small complete plants. The inset curve on Fig. 1 shows the more reasonable figures for the self-contained pulverisers.

Fig. 1.

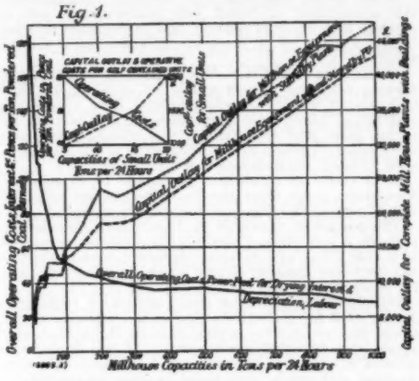

Capacities of Small Units Tons per 24 Hours
Optimal Outlay
Overall Operating Cost
Depreciation, Labour
Mill-house Capacities in Tons per 24 Hours

FIG. 1. Curves showing relation between cost of mill-house plants for various capacities per 24 hours and over-all operating costs.

Fig. 3.

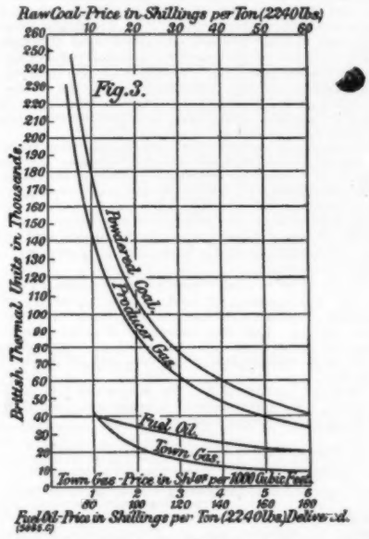

Raw Coal-Price in Shillings per Ton (2240 lbs.)
Powdered Coal
Producer Gas
Fuel Oil
Town Gas
Town Gas-Price in Shillings per 1000 Cubic Feet
Fuel Oil-Price in Shillings per Ton (2240 lbs.) Delivered.

FIG. 3. The number of British thermal units secured for one penny for commercial fuels at various prices.

From these curves a ready estimate can be made as to when it will pay to use pulverised fuel, but in doing so the very many important advantages and economies introduced by the use of powdered coal must not be overlooked. There is, unfortunately, no possibility of showing on these curves such advantages as reduction in labour, increased output of furnaces, reduced metal loss, better work and better working conditions, &c., all of which collectively will place the whole question of mill-house costs in a very different light.

The curves shown in Fig. 2 represents the overall cost for the quantity of pulverised coal required for performing the same work as 1 ton of the same coal hand-fired. Six curves are given for raw coal at 10*s.*, 20*s.*, 30*s.*, 40*s.*, 50*s.* and 60*s.* per ton respectively, and intermediate values between two coal price curves can be obtained with sufficient accuracy for making any preliminary estimate for equivalent costs of coal in powdered form.

In order to arrive at the points for constructing the curves, the value of a one-third reduction in coal used, when pulverised coal is supplied, has been deducted from the cost of raw coal. To this result the overall operation cost for the size of plant in question taken from Table IV has been added in each case.

For instance, with coal at 30*s.* per ton the value of a one-third reduction in fuel consumption will be 10*s.*, but the overall cost of operation for a powdered coal plant having a capacity of 220 tons per day (see Table VI) is 3*s.* 7½*d.*, so that the net value of powdered coal for the purpose of plotting the curve for a 30*s.* coal will be 23*s.* 7½*d.* as against 30*s.* for hand-firing.

Graph Fig. 3 indicates the relative values of fuels in British thermal units obtainable for 1*d.*, the fuels considered being powdered coal, producer gas, fuel oil and town gas.

In order to arrive at a basis which is as fair as possible for comparison with other fuels, the operating cost for running a powdered-coal plant and the overall expense connected with conveying and burning the fuel at the furnace have been added to the cost of the raw coal. In the present case this operating cost has been taken at 4*s.* per ton of coal pulverised, a reasonable figure for a plant capacity of 200 tons per 24 hours.

For the same reason, 4*s.* per ton has been added to the cost of coal gasified in producers of equal total capacity to the powdered coal plant so as to allow for operating costs, interest and depreciation on the producer plant, and it is presupposed that the gas will be burned under natural air-draught conditions.

For powdered coal, fuel oil and town gas, thermal efficiencies of 100 per cent. have been accepted. Cost of power at ½*d.* per unit for air blowers for oil and town gas has been added to the purchase prices of these fuels.

The calorific value of the raw coal has been assumed at 14,000 British thermal units per lb., that of oil at 19,000 British thermal units, and town gas 550 British thermal units net per cubic foot.

THE ADVANTAGE OF USING COAL IN POWDERED FORM.

Mr. Joseph Harrington* writes: "In the producer there is a succession of losses which reduce the available heat in the gas to a considerable extent, and in the mechanical stoker there are unavoidable losses due to various forms of incomplete combustion. Only in the case of powdered coal is the actual solid fuel both gasified and completely consumed directly within the chamber to be heated. With perfect pulverisation the entire mass is burned in suspension, and in actual practice but a small fraction of 1 per cent. is actually lost in the flue dust or slag pan.

Fig. 2.

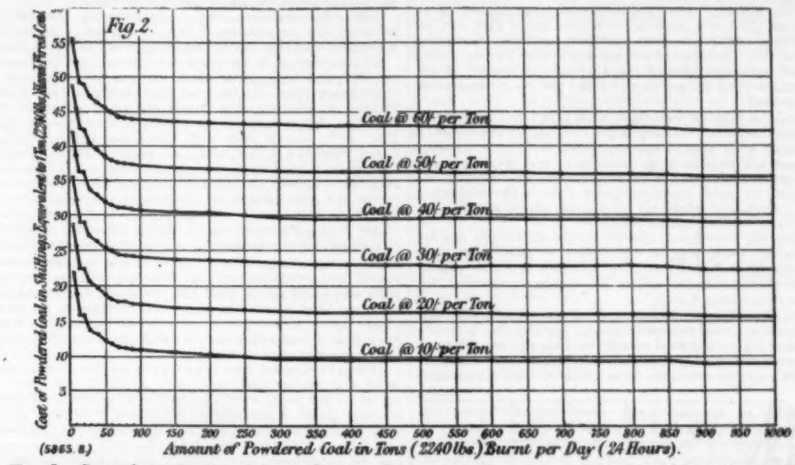

Coal @ 60/- per Ton
Coal @ 50/- per Ton
Coal @ 40/- per Ton
Coal @ 30/- per Ton
Coal @ 20/- per Ton
Coal @ 10/- per Ton
Cost of Powdered Coal in Shillings Equivalent to Ton (2240 lbs.) Hand-Fired Coal
Amount of Powdered Coal in Tons (2240 lbs.) Burnt per Day (24 Hours).

FIG. 2. Cost of powdered coal for performing the same work as 1 ton (2,240 lb.) of hand-fired coal. Assuming 33⅓ per cent. saving in fuel by the use of powdered coal and as an offset against the value of the fuel saving the cost of preparation and burning powdered coal has been added. Costs given for plants of various capacities and for six prices of raw coal.

TABLE IV.—CAPITAL OUTLAY AND OPERATING COSTS OF MILL-HOUSE PLANTS OF VARIOUS CAPACITIES.

Daily Output in Tons.	Labour. Cost per Ton.	Power. Cost per Ton.	Dryer Fuel per Ton.	Repairs per Ton.	Without Stand by Plant.				With Stand by Plant.			
					Cost of Plant, including Building.	Interest per Ton 6 per Cent.	Depreciation per Ton 10 per Cent.	Total Cost per Ton.	Cost of Plant.	Interest 6 per Cent.	Depreciation per Ton 10 per Cent.	Total Cost per Ton.
	s. d.	*s. d.*	*d.*	*d.*	£	*s. d.*	*s. d.*	*s. d.*	£	*s. d.*	*s. d.*	*s. d.*
5	4 2	1 6	5	4	3,500	2 9½	4 8	13 10½	4,250	3 4½	5 7	15 4½
10	2 1	1 3	5	4	6,700	2 8	4 5½	11 2½	6,700	2 8	4 5½	11 2½
15	1 8	1 3	5	4	6,700	1 10	3 0	8 6	6,700	1 10	3 0	8 6
20	1 10½	1 3	5	4	8,650	1 9	2 10½	8 6	9,650	1 11½	3 3	9 1
30	1 5	1 3	5	4	9,300	1 3	2 1	6 9	10,300	1 4½	2 3½	7 1
40	1 6½	1 3	5	5	9,300	0 11	1 7	6 1½	10,300	1 0½	1 9	6 5
50	0 10	1 3	5	4	11,100	0 10½	1 6	5 2½	12,700	1 0	1 8½	5 6½
60	0 8½	1 3	5	4	11,100	0 9	1 3	4 8½	12,700	0 10½	1 5	4 11½
70	0 7	1 3	5	5	11,100	0 7½	1 1	4 4½	12,700	0 8½	1 2½	4 7½
80	0 9	1 3	5	5	11,100	0 6½	0 11	4 3½	12,700	0 7½	1 1	4 6½
90	0 8½	1 3	5	5	11,100	0 6	0 10	4 1½	12,700	0 6½	0 11	4 3
100	0 7½	1 3	4½	5	13,500	0 6½	0 11	4 1½	14,500	0 7	0 11½	4 2½
150	0 5	1 3	4½	5	15,000	0 4½	0 8	3 6½	18,100	0 5½	0 9½	3 9½
200	0 4	1 3	4½	4½	18,500	0 4½	0 7½	3 4½	23,600	0 5½	0 9½	3 7½
250	0 4½	1 3	4½	4½	18,500	0 3½	0 6	3 2½	22,550	0 4½	0 7½	3 4½
300	0 4	1 3	4½	4½	19,100	0 3	0 5	3 0½	23,150	0 4	0 6½	3 2½
350	0 3½	1 3	4½	4½	20,550	0 2½	0 4½	2 11½	24,600	0 3½	0 5½	3 0½
400	0 3½	1 3	4½	4½	22,500	0 2½	0 4½	2 9	25,850	0 3½	0 5½	3 0½
450	0 3½	1 3	4½	4½	24,000	0 2½	0 4½	2 8½	27,350	0 3	0 5	2 11½
500	0 4	1 3	4½	4½	25,600	0 2½	0 4½	2 8½	29,650	0 2½	0 5	2 11½
550	0 3½	1 3	4½	4½	27,500	0 2½	0 4½	2 8½	31,550	0 2½	0 4½	2 10½
600	0 3½	1 3	4½	4½	29,100	0 2½	0 4	2 10½	34,750	0 2½	0 4½	2 11
650	0 3½	1 2½	4½	4½	30,900	0 2½	0 3½	2 7	36,550	0 2½	0 4½	2 10½
700	0 3½	1 2	4½	4½	32,500	0 2½	0 3½	2 8½	38,150	0 2½	0 4½	2 9½
750	0 3½	1 2	4½	4½	34,300	0 2½	0 3½	2 8½	39,250	0 2½	0 4½	2 9½
800	0 3½	1 1½	4½	4½	35,900	0 2½	0 3½	2 8	42,450	0 2½	0 4½	2 9
850	0 3½	1 1	4½	4½	37,500	0 2½	0 3½	2 7½	44,050	0 2½	0 4½	2 8½
900	0 2½	1 0	4	4	39,200	0 2½	0 3½	2 4½	43,900	0 2½	0 4½	2 5
950	0 2½	1 0	4	4	41,200	0 2	0 3½	2 4	45,900	0 2	0 4½	2 4½
1,000	0 2½	1 0	4	4	42,500	0 2	0 3½	2 3½	47,200	0 2	0 4	0 4½

Cost of plant covers normal foundations and erection.

TABLE V.—CAPITAL OUTLAY AND OPERATING COSTS OF SMALL SELF-CONTAINED UNITS.—AERO "PULVERISER" PLANT.

Daily Output in Tons.	Output per Hour.	Labour Cost per Ton.	Power Cost.	Dryer Fuel.*	Repairs per Ton.	Interest 6 per Cent.	Depreciation.	Total Cost.	Labour Hours per Day.	No. and Duration of Shifts.	Cost of Plant.†
	tons.	*s. d.*	*s. d.*		*d.*	*d.*	*s. d.*	*s. d.*		Hours.	£
5	¼	2 7	2 10½	—	1½	9½	4 4	7 8½	10	2–5	1,000
10	½	1 9½	2 0	—	1½	6½	0 10	5 3	14	2–7	1,250
15	1	1 4½	2 0	—	1½	4½	0 8	4 6½	16	2–8	1,500
20	2	0 8	1 7	—	1½	4½	0 8	3 5½	10	2–5	2,000

* No dryer used as a rule with this type of plant.
† Bare cost of pulveriser and motor only.

* American Society of Mechanical Engineers, October, 1916.

"On account of the fuel being conveyed into the furnace by the very air which is afterwards to be used in its combustion, and on account of the diffusing of the coal throughout the air in a cloudlike formation, there is a possibility of a mixture which can be secured by no other means. Each particle of coal is surrounded by a particle of air, and on account of the extreme fineness of the particles practically instantaneous oxidisation occurs. The result is efficient combustion, and we have to deal only with the effects of the high temperature thereby obtained."

It has already been pointed out that higher temperatures than are possible with any other fuel can be maintained in powdered coal-fired melting furnaces, because the quantity of excess air is but 20 per cent., whereas with stoker and hand-firing the excess of air may range from 50 per cent. to 200 per cent., and even 300 per cent.

It will be readily seen that with powdered-coal firing the gases due to combustion of the fuel will be appreciably less than with the usual methods, and consequently the gases will remain in the furnaces for a longer period. The heat transference with pulverised-fuel firing must, therefore, be much more complete than is the case with larger volumes of relatively cool gases which result from hand-firing or even stoker-firing.

Values for heat losses due to excess air supply can be ascertained from Fig. 4. Moisture in fuel, imperfect combustion, carbon in clinker and ash are also causes of considerable losses which are entirely removed by the use of powdered coal.

Heat Loss due to Moisture in Fuel.—Under certain conditions it would probably pay to dry out the moisture contained in coal before using the fuel in the ordinary way on hand-fired grates or mechanical stokers, for, in order to evaporate and drive off 1 lb. of the moisture

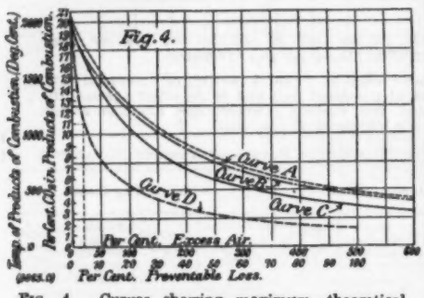


FIG. 4. Curves showing maximum theoretical temperatures obtainable with varying quantities of excess air, when burning pure carbon and bituminous coal, also showing preventable losses due to excess of air supply.

when the fuel is in the firing chamber, approximately 1,250 British thermal units are wasted in accomplishing this and superheating the resultant steam. This is one of the reasons why dry pulverised fuel burned in a furnace combustion chamber gives such a high heat efficiency.

Lignite generally contains from 20 per cent. to 30 per cent. of moisure in the raw state, and a certain fuel, having a British thermal unit value of 12,378 per lb. of dry combustible or 10,675 British thermal units per lb., based on the analysis of the lignite, had only a heat value of 3,854 British thermal units undried. This fuel, dried to 7 per cent. moisture, gave a water evaporation of 8·86 per lb. combustible, and with 1 per cent. moisture 10·90 lb. water evaporation. When fired undried on stokers the water evaporation was but 4 lb.

For every 1 per cent. of moisture in coal it can be taken that the heat value per lb. of fuel will be reduced by 12·5 British thermal units, so that powdered coal which should be dried to this degree will show but a loss of 12·5 British thermal units, whereas a similar coal containing 10 per cent. moisture would show a loss of 125 British thermal units per lb. of fuel.

Heat Loss due to Imperfect Combustion.—How often does one see flame issuing from the top of a stack in the iron districts, and what a loss of heat this means. Such conditions are presumably brought about by the generation of CO at the fire-grate, which partially burns in contact with oxygen drawn in at furnace cracks and completes its combustion on emergence from the stack.

With powdered coal such uneven firing conditions can be readily prevented over a very wide range of fuel consumption, for complete combustion under all conditions can be made to take place within the actual furnace chamber.

Loss of Coal in Ash and Clinker.—A series of tests were carried out in America to ascertain the value of the carbon lost in ash and clinker withdrawn from boiler pits. The following results are given by Mr. W. G. Wilcox:*—

Overfeed stokers, 25 per cent. unburned carbon in the ash = 4·6 per cent. actual coal lost.
Chain grate stokers, 35 per cent. unburned carbon in the ash = 6·1 per cent. actual coal lost.
Hand-firing, 35 per cent. upwards carbon in the ash = 6·5† per cent. and upwards.

In powdered-coal firing less than one-half of 1 per cent. carbon will be found in ash and clinker when conditions are properly adjusted.

CURVES OF COMBUSTION EFFICIENCIES, &C.

In Fig. 4 a series of curves applicable to the working of solid fuel furnaces are given. From these it will be seen at a glance how rapidly the overall thermal efficiency of furnaces heated by means of solid fuel decreases with the increase of excess air, which may be due to incorrect design or careless operation.

Take, for instance, the curve showing the relation between the percentage of CO_2 in the waste gases from a furnace and the corresponding preventable fuel loss.

In this case it is assumed that when the CO_2 content has dropped to 1·5 per cent. the amount of excess air is so great that all the heat liberated from the fuel is utilised in heating this excess air to a sufficient temperature to maintain an efficient chimney draught. The curve shows that with the usual CO_2 content of 5 per cent. to 6 per cent., as in hand-firing practice, the preventable loss is as high as 25 per cent. of the total fuel burned, and as the CO_2 content drops below this figure the preventable loss increases very rapidly. On the other hand, with a CO_2 content of 14 per cent. to 16 per cent., representing average practice for powdered-coal firing, the preventable loss becomes almost negligible.

From the temperature curve it will be seen that a waste gas temperature of 500 deg. C. corresponds with an excess air value of 430 per cent., and it has been assumed that conditions under which there is an excess of air equal to 500 per cent. will be the limit at which preventable loss will occur, a sufficient chimney draught being assured at the same time.

It will be noticed that the CO_2 content may be dropped from the theoretical maximum of 20·7 per cent. to about 11 per cent. with a corresponding loss of efficiency of only about 5 per cent. After this, however, as the CO_2 content is lowered the loss of efficiency increases rapidly. A CO_2 content of 14 per cent. to 16 per cent. can be considered exceptionally good practice, seldom regularly obtained with solid fuel and hand-firing.

Consider next the curve showing the relation between CO_2 content of the waste gases and excess air supplied to the furnaces over and above the quantity theoretically necessary to burn the fuel.

Owing to its lump formation and to the usual methods of burning solid fuel the complete oxidation of the carbon cannot take place at a sufficiently high rate under ordinary conditions of firing unless some excess air is supplied. This excess, however, is usually much higher than is really necessary, and inspection of the curve connecting CO_2 with excess of air shows how rapidly the CO_2 content drops with increase in the supply of air.

The other two curves shown indicate the relation between the theoretical maximum temperature of the products of combustion when burning pure carbon and that when burning a representative sample of bituminous coal when supplied with no excess air, and also for varying proportions of excess air.

From these curves it will be seen that with even 25 per cent. excess air the temperature of combustion falls 300 deg. C., whilst with the general average of 300 per cent., excess air the temperature is less than one-third of the possible maximum when no excess air is present. Thus with coal in powdered form the oxidation of the small particles is instantaneous, preventable loss is very small, and very nearly maximum flame temperature are obtainable.

The extreme importance of the effect of excess air on resultant combustion of fuels has not been sufficiently realised, and emphasis on this fact cannot be too strongly made.

GENERAL CONSIDERATIONS RELATING TO SUCCESSFUL APPLICATION OF PULVERISED FUEL.

In the application of powdered-coal firing, the five chief points to be constantly kept in mind are: (1) Elimination of the explosion danger: (2) efficient drying of the raw coal; (3) fine pulverisation; (4) avoidance of complicated equipment; (5) reliability of fuel supply.

(1) *Elimination of the Explosion Danger.*—It is evident from reports received by the author that several accidents occurred in the early development of systems depending upon the transportation of coal dust in suspension in a current of air.

Mr. S. H. Harrison* mentions the occurrence, several years ago, of a disastrous explosion at a large pulverised coal plant due to blowing the fuel through large ducts by means of fans. "This method of transportation should be condemned; a spark from a motor or from defective wiring may ignite this highly inflammable mixture." In present-day systems of this description the mixture of coal dust and air as supplied through the conveying pipes is not of an explosive nature, so long as the correct working conditions are maintained, and this is the only feasible manner of supplying powdered coal to numbers of very small furnaces, but the disadvantages of such systems appear to outweigh the advantages when fuel is to be burned in considerable quantity.

It appears to the writer to be far preferable to distribute the powdered coal into bins at the boilers of furnaces, thereby preventing storage in bulk at any one point.

(2) *Coal Dryers.*—It is quite essential that all coals be thoroughly dried, and for this purpose efficient apparatus should be installed. The coal at the termination of this process should leave at a temperature not higher than 250 deg. F., and with a moisture content under 1 per cent., otherwise overheating is likely to take place in the dry coal storage bin, or if used at once, overheating and possibly firing, will be experienced in the pulverisers.

That coal dust should be as dry as possible is necessary for the satisfactory transportation of the fuel by any of the usual means; screw conveyors, air pressure, or in a current of air. This is a point worth special consideration in this country, where the atmosphere may contain considerable moisture, for pulverised coal will readily reabsorb water from the air and become sticky and difficult to handle.

When moist, coal dust will naturally coagulate and the advantages of initial fine pulverisation will be entirely lost, the fuel passing into the furnace in small lumps instead of in intimate mixture with the air supply.

It has been stated that dust-settling chambers in connection with coal dryers should be avoided, for there is a danger of the accumulated coal dust overheating and firing, which may well cause an explosion of the mixed gases and coal dust in the chamber, especially when cracks develop in the brick walls of the chambers, thus allowing the infiltration of air.

It is therefore considered preferable to exhaust the dust-laden gases from the dryer by means of a fan and to remove the fine dust in a cyclone separator.

The danger of explosion in dust-settling chambers is perhaps a very remote one, for the Cummer dryers are as a rule fitted with settling chambers, and the author has inspected Cummer dryers which have been running for years without any such mishap.

With further regard to this question of thoroughly drying coal for pulverisation, and in reference to the power required for the drying process, Mr. C. J. Gadd* makes the following statement: "If the moisture is allowed to exceed three fourths of 1 per cent., operating troubles will result, and these become intensified the higher the percentage of moisture.

"It is easier to dry coal to ½ per cent. moisture or less than it is to maintain it in this state. This is explained by the fact that the moisture driven off from the coal in the process of drying saturates the hot air contained in the dryer cylinder. In this highly saturated condition the air follows the dried coal through the dust-proof conveying system to the enclosed storage bin. As the coal and air cool, moisture is precipitated and the volume of the air diminished, with the result that more warm saturated air is drawn from the dryer. These conditions, obviously, meet the requirements of a "still" of fair proportion.

"The precipitation of moisture resulting from the cooling process of the coal and air may be almost entirely overcome by placing ventilating shafts on the storage bin and the high points of the conveying system connected with the outside air. Each shaft should be equipped with a ventilator of approved type, and proper provision should be made to collect and deflect any condensation in the ventilating shafts, so as to prevent its return.

"It is thus evident that in the process of drying, through the medium of heat, a small quantity of the expelled moisture will find its way back into the coal after cooling. For this reason it is good practice to gauge the dryer so that the resultant product leaving the dryer will contain less than one-half of 1 per cent. moisture."

Table VI, prepared by Mr. Raymond,† is useful in showing the approximate consumption of coal for reducing the moisture content of coals.

TABLE VI.—*Fuel Required to Dry Coal.*

Percentage of Moisture in Coal.	Coal Consumed per Hour in Pounds in Operating Dryer.* 160	230	350	540	715	900
	Capacity of Dryer in Tons per Hour.					
1	19·5	28·1	43·2	66·8	88·9	113·0
2	15·3	25·1	33·5	51·8	68·9	86·3
3	12·7	18·2	27·5	42·4	56·4	70·6
4	10·7	15·5	23·6	36·4	48·4	60·6
5	9·3	13·3	20·3	31·3	41·6	52·2
6	8·1	11·7	17·7	27·4	36·4	45·7
7	7·2	10·4	15·7	24·1	32·1	40·2
8	6·5	9·4	14·3	22·0	29·2	36·7
9	5·9	8·5	12·8	19·8	26·4	33·0
10	5·4	7·8	11·8	18·4	24·4	30·4
11	5·0	7·1	10·8	16·7	22·2	27·8
12	4·6	6·6	10·0	15·3	20·2	25·2
13	4·2	6·1	9·3	14·4	18·9	24·0
14	3·9	5·7	8·6	13·3	17·7	21·9
15	3·7	5·3	8·0	12·3	16·3	20·2

* Coal to have 14,000 British thermal units per pound.

The Fuller and Bonnot dryers are referred to later in the description of plant used with these systems. The Cummer dryer is another type which gives excellent results in practice.

The following is a description of this drying process.

Three-quarters of the heated air and gases enter the cylinder by way of the 10½-in. diameter heat inlet openings. The balance enters the rear end. Through the hooded heat inlet openings at the front end of the cylinder the heated air and gases at highest temperatures come in direct contact with the wet, cold material as it enters. By the admission of cold air through the sliding doors in the dryer setting, the temperature of the heated air and gases is reduced towards the rear end to suit the material as it becomes drier and susceptible to injury from high

* American Chemical Society, May 31, 1918.
† Slight difference evidently due to analysis of coals used.

* *Engineering Magazine*, February, 1916.

* *Journal of the Franklin Institute*, September, 1916.
† Proceedings of the Engineers' Society of Western Pennsylvania, October, 1913.

temperatures. The lowest temperatures and the least circulation are found at the rear end of the cylinder, where the material is most dry and dusty. The idea is—high temperatures where the material is wet and cannot be injured, moderate temperatures where the material is partly dried, and low temperatures at the rear or discharge end of the dryer, where the material is practically dry.

The dryers seen by the author were fitted with mechanical stokers, but they can be hand-fired or arranged for use with powdered fuel. As a rule, when drying coal the dryer is provided with a dust-settling chamber and the exhaust fan is placed on the chimney side of this chamber and not directly on to the head of the cylinder.

The Ruggles-Coles dryer has been extensively used in America for drying coal. A "phantom" view of this apparatus is shown in Fig. 5.

In this case the hot gases from the combustion chamber enter the central tube of the dryer and pass through to the end housing without coming in contact with the fuel to be dried. The gases have then cooled down sufficiently for passing over the fuel on their way back through the cylinder to the exhausting head seen in the illustration.

(3) *Fine Grinding.*—For boiler firing and for use in metallurgical furnaces fine grinding is essential, otherwise instantaneous and complete combustion is impossible, the result being loss of unburned carbon in the ash and slag deposit in the combustion chamber or on the boiler tubes.

In one instance the pulverising plant was changed so as to obtain a product, 95 per cent. of which would pass through the 100-mesh screen; previously, coal dust ground to a fineness of 88 per cent. through the 100-mesh screen was used. After the change had been effected definite tests showed an increase in furnace efficiency of 12 per cent., and whereas with the coarser fuel ash troubles were constant, these were almost entirely removed when the finer coal dust was used.

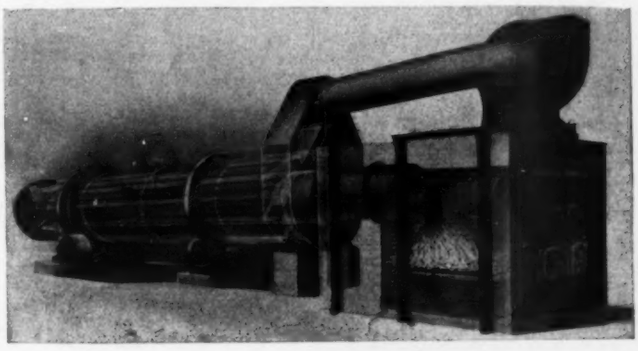


FIG. 5. RUGGLES-COLES DRYER.

(4) *Simplicity of Equipment.*—In this connection it will be interesting to make reference to the trend of opinion in Germany, where the use of fuels in pulverised form has undoubtedly been developed to a considerable extent during recent years upon lines of simplicity of machinery and handling plant. The following is a review of German practice* :—

"In German plants particular attention is directed to simplicity of construction of the grinder, in which respect the German construction differs materially from American, and even though some typical American crushers—*e.g.*, the Fuller-Lehigh—have been adopted in some German plants, as a rule they have not found ready application in that country, and for the same reason the high-speed machinery of this type built in Germany itself has not been much used.

"Where the plants using powdered coal have efficient repair shops and skilled mechanics available, oscillating crushers and similar apparatus can be used without much difficulty and with certain advantages; otherwise, however, the saving effected by their use will be more than eaten up by interruptions in the operation of the plant.

"In the modern German plant nearly everywhere one finds slow-running grinders with a large area of crushing, mainly of the ball and tube mill type. The larger amount of power consumption as compared with high-speed machinery does not particularly matter here. Ball and tube mills are as a rule located one over the other, so that the grist produced by the ball mill can go directly to the tube mill and be converted into fine powder.

"In order to improve the screening action, several types of ball mills have been placed on the market; for example, the so-called Cementor mill of Polysius, Dessau, Germany. Contrary to the usual practice in ball mills, this construction has unperforated crushing plates, these plates being located between the walls in such a manner as to form stages with each other. With this construction, the grist is forced to run through the entire path of the grinding, passes over the sieve, and is then partly returned in a uniform manner into the grinding drum.

"The high cost of foundations which such an arrangement involves, and the effort to simplify still more the grinding, led to the design of a machine which could carry out the crushing and fine grinding in one continuous series of operations. This resulted in the design of a combined crusher and grinder, forming one cylinder, a design particularly adapted for use in steel mills because of its extraordinary simplicity. This type of machine, called "Solo" mill, is likewise built in Germany by G. Polysius, Dessau, and consists of a seamlessly welded sheet cylinder running in circular bearings. This cylinder is divided by a wall into two chambers, one the crushing chamber with hard steel plates and steel balls, and the other the fine grinding chamber with Silex lining and quartz stones. The crushing chamber is surrounded with screens, and is enclosed in a sheet steel jacket, and can crush pieces as large as a man's fist. This grist then falls through slots at the end of the crushing chamber upon screens over which it travels, just as in the Cementor, to the admission side of the grinding mill. What remains over the screen is carried back into the crushing chamber, while that which passes through the screen is delivered to the grinding chamber and handled there.

"As compared with the oscillating and Fuller mills, this design has the advantage of handling pieces to the size of a man's fist; as compared with mills which require special separators, as in the Raymond crusher, there is the advantage that the Solo mill uses no cyclones, &c. In addition to that, there is the very important consideration that this type of mill insures to a very large extent against the occurrence of fires and explosions; where the material handled has to be transferred from one apparatus to another, it is very difficult to provide against its escape and the formation of inflammable or explosive mixtures with air.. In this case, this source of danger is eliminated to a large extent, and the author states that explosions have never occurred in mills of the Polysius type. The objection is often made to crushers operated with screens on account of their rapid wear; in the Solo mill these screens consist of perforated steel sheets of high resistance, in addition to which the construction is such that large pieces of iron that cause most of the wear cannot reach the screen."

In this account one or two points are of special interest. The preference maintained for the use of ball and tube mills as against high-speed mills of the Fuller or Raymond types has not been ratified by American engineers.

The large amount of power required for the ball and tube mill outfit combined with high cost of foundations are serious objections, and in practice it is understood that the cost of maintenance for the so-called high-speed mills (140 revolutions or so per minute) has not been greatly in excess of the upkeep cost of ball and tube mills working in America. The Raymond mill certainly requires additional power for extracting the fine coal dust by air suction from the mill, but, as regards screen damage, most mills of this type, such as the Fuller, are fitted with heavy grid-protecting cylinders, which prevent pieces of iron, which have not been removed by the magnetic separator, from piercing the fine screen.

Accidents of this nature to the screens of Fuller Mills have been reported, but these have been very infrequent when efficient magnetic separators have been installed and the operation of changing a screen only means a delay of half an hour at most. Any damaged screen can be repaired and re-used, and the actual wear of mill screens is inconsiderable.

(5) *Reliability of Fuel Supply—Transportation and Storage of Coal Dust.*—It will be readily acknowledged that it is not very wise to rely entirely upon powdered coal stored in bulk at any one point if this can be avoided. If the fuel supply for a whole works or department is located at one point, any accidental breakdown of the fuel transport machinery will cut off the supply to the whole plant. Apart from this reason, there is always more danger of spontaneous combustion in a large mass of coal than in smaller quantities. Consequently it is best to convey the coal as it is pulverised to bins at the boilers or furnaces, which should have sufficient capacity to carry over any short period of breakdown of mill or transport gear. The use of screw conveyors has for these reasons many adherents in America, and is to be preferred in cases where they can be conveniently applied. Where greater risks can be taken, or for special purposes, one or other of the several means of conveying coal other than by screw conveyors can be used to greater advantage.

(*To be continued.*)

* Journal of the American Society of Mechanical Engineers, November, 1915.

CATALOGUES.

Gear-Box Grease.—Messrs. Sterns, Limited, Finsbury-square, E.C. 2, send a booklet describing their special grease for motor car change-gear boxes; it is made to a consistency that enables it to cling to the wheel teeth during use.

Bascule Bridges.—These are well described in a catalogue received from the Strauss Bascule Bridge Company, Chicago, U.S.A. Many excellent examples are illustrated and the trunnion bearing, counterweight, and general construction and operation explained.

Aircraft.—Messrs. Ruston and Hornsby, Limited, Lincoln, have recently issued an extremely interesting booklet in celebration of the one-thousandth airplane made at their works. The booklet was prepared during the war, but its circulation was forbidden until recently.

Steam Jet Air Pumps.—The Wheeler Condenser and Engineering Company, New Jersey, U.S.A., send a catalogue giving particulars with some line drawings of this type of pump for use with surface condensers. Two or more steam jets work in series with a condenser between the jets. Figures of efficiency are also given.

Steam Turbines.—A catalogue from the Delaval Steam Turbine Company, New Jersey, U.S.A., shows marine installations up to 13,500 h.p. These are fitted with double helical pinion and spur reducing gear, of the single reduction type, attaining propeller speeds of 120 r.p.m. to 90 r.p.m.

Electric Batteries.—A priced catalogue of batteries for motor car starting and lighting comes from the Hart Accumulator Company, Limited, Stratford, London. There are seven sizes for 6 volts and six sizes for 12 volts. All necessary particulars of size, capacity, &c., are clearly tabulated.

Electric Welding.—Four lists dealing with plant, equipment, sundry accessories and electrodes used in electric welding are issued by the Equipment and Engineering Company of New York and Norfolk-street, Strand, W.C.2. These give sufficient illustrations with useful details of the capacity, form, &c., of the various items.

Pyrometers.—The importance of standards and of checking in pyrometry is discussed in a catalogue received from the Leeds and Northrup Company, Philadelphia, U.S.A., the conclusion being that three platinum couples should be kept for comparison. The workmen soon know when the instruments are wrong and are liable to lose confidence in them altogether unless they are maintained in correct condition.

Testing Machine. Messrs. Bradley and Turton, Limited, Kidderminster, send a catalogue giving a concise and clear description of the Bradley-Richards 30-ton testing machine. This is a vertical machine of simple and powerful build with hand or power drive for the fluid (mineral oil) pump. The machine is suitable for tensile tests of bars of 1 sq. in., iron sectional area up to 30 tons, or ½ sq. in. up to 60 tons, or ¼ sq. in. up to 120 tons, and also deflection tests. With special attachments it is suitable for bending, compression and Brinell hardness tests.

Electric Motors.—An exceptionally well-arranged and clearly printed priced list of small motors comes from Messrs. Higgs Brothers, Summer Hill-street, Birmingham. In continuous-current shunt motors, 110 volts, there are 15 sizes between 0·15 brake horse-power and 1 brake horse-power, and 30 more variations of power up to 28 brake horse-power. In most of these there are two to five or more variations of speed, *e.g.*, the 5 brake horse-power motor is made for speeds of 300 r.p.m., 450 r.p.m., 2,200 r.p.m., and 3,700 r.p.m. Prices are also given in full detail for starters, pulleys, slide rails, &c. One, two and three-phase induction motors are also included, and lists of spare parts.

Shredding Machines.—A catalogue of machinery for tearing wood, bark, beans and other fibrous material into shreds comes from the Jeffrey Manufacturing Company, Columbus, O., U.S.A. They are rotary tearers working against bar gratings. A considerable range of capacities is made to standards, all the parts being replaceable. For example, wood shredding machines are listed in eight sizes, with capacity for tearing from under 1 ton up to 15 tons of wood per hour. The rotor speed is over 1,000 r.p.m. and the power consumed is 20 h.p. to 120 h.p. for the capacities quoted. Conveyors and supplementary plant are also described and full measurements given.

DUST FIRES IN GRAIN-THRESHING MACHINES.—According to Bulletin 379 of the United States Department of Agriculture, explosions and fires in threshing machines are not by any means infrequent. Since 1914 more than 700 fires have been recorded in the Pacific north-west alone, there being about 300 each in the years 1914 and 1915 with which the Bulletin deals particularly. Of the total number of machines thus affected in 1915, 27 per cent. were a total loss, and in 34 per cent. of the cases there was partial damage; in the other cases little damage was done. More than 80 per cent. of all the fires were due to smut-dust explosions, and 76 per cent. originated near the cylinder on the front part of the machine; the cause of the inflammation was electric sparking from the machinery The remedies adopted are threefold: Automatic fire extinguishers, especially designed for threshing machines exhaust fans to remove smut and dust from the separator; effective earthing of the machine to prevent the accumulation of static electric charges. These remedies have proved successful in many installations, in which no further fires have occurred.

"ENGINEERING" ILLUSTRATED PATENT RECORD.

SELECTED ABSTRACTS OF RECENT PUBLISHED SPECIFICATIONS UNDER THE ACT OF 1907.

The number of views given in the Specification Drawings is stated in each case; where none is mentioned the Specification is not illustrated.

Where inventions are communicated from abroad, the Names, &c., of the Communicators are given in italics.

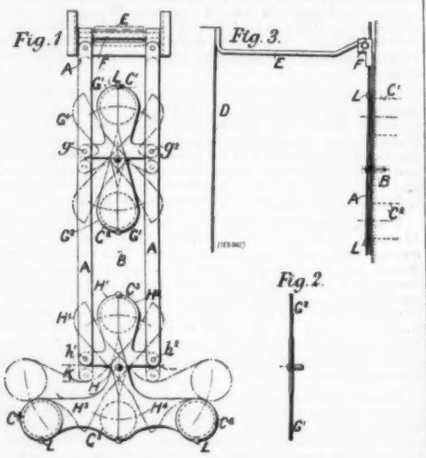
Copies of Specifications may be obtained at the Patent Office, Sales Branch, 25, Southampton Buildings, Chancery-Lane, W.C., at the uniform price of 6d.

The date of the advertisement of the acceptance of a Complete Specification is, in each case, given after the abstract, unless the Patent has been sealed, when the word "Sealed" is appended.

Any person may, at any time within two months from the date of the advertisement of the acceptance of a Complete Specification, give notice at the Patent Office of opposition to the grant of a Patent on any grounds mentioned in the Act.

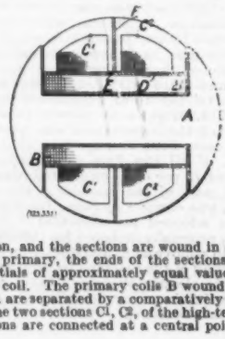
ELECTRICAL APPARATUS.

125,042. Johnson and Phillips, Limited, Charlton, London, and W. A. Walker, Charlton, London. Electric Switchboards. (3 *Figs.*) December 14, 1918.—The invention relates to high-tension electric switchboards of the truck type. According to the invention, a frame of metal strips of small width and light weight is adapted to be raised by the counter-weighted arms of a pivoted lever on the withdrawal of the truck, the movement of the arms covering apertures in the fixed cubicle; when the truck is close to the cubicle a projecting bar secured to the truck forces the sliding frame slightly downwards and thereby causes the pivoted arms to rotate in their own planes and uncover the apertures. A is a frame adapted to slide in contact with a fixed cubicle B, in which are apertures C_1-C_6, through which plug contacts carried by the truck D pass to engage with fixed sockets in the cubicle B. The free end of the projecting bar E secured to the truck D engages with the upper surface of a roller F provided in the top of the frame A. When the truck D moving in the direction of the arm is brought into proximity to the stationary cubicle, the lower part of the bar E



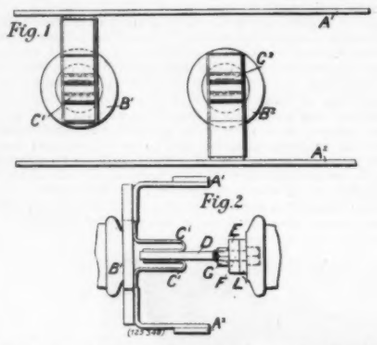
rests on the roller F and causes the roller and with it the frame A to be lowered from the position shown in full lines, in which the apertures are covered, to the position shown by the broken lines, in which the apertures C_1-C_6 are uncovered. Arms G_1, G_2, pivoted to the unexposed side of the front surface of the cubicle B and to the frame A at g_1 and g_2, cover the apertures C_1, C_2. Similarly arms H_1, H_2, pivoted at H to the cubicle and to the frame at h_1, h_2, are adapted in the position shown by full lines to cover the apertures C_3, C_4. Extensions H_3, H_4, of the arms H_1, H_2, cover, respectively, the apertures C_4, C_6. The arms H_3, H_4, are loaded sufficient to automatically raise the frame A and thereby cover the apertures as soon as the truck has been withdrawn sufficiently far to allow the shaped free end of the projecting bar E to engage with the roller F. The descent of the frame A through a small vertical distance K causes the arms to move through arcs about the pivots G, H, sufficient to fully uncover the apertures. Stops L limit the movement K of the arms when in the closed position and also secure the arms so that they cannot be forced back from the front side. (*Sealed.*)

125,331. The British Lighting and Ignition Company, Limited, London, and E. O. Turner, London. Magnetos. (1 *Fig.*) November 14, 1918.—According to the invention in a magneto in which the high tension winding is divided into two sections separated by an insulating partition, the inner layers of each winding are joined together, but insulated from the primary and from the frame, at points on either side of the



central partition, and the sections are wound in opposite directions over the primary, the ends of the sections, which are at opposite potentials of approximately equal value, being at the exterior of the coil. The primary coils B wound on the core of the armature A are separated by a comparatively thin insulating layer D from the two sections C^1, C^2, of the high-tension winding. The two sections are connected at a central point E, which is insulated from the armature core and from the primary winding, and the coils are wound in opposite directions towards the armature cheeks. There should be as nearly as possible the same number of turns in each section, in which case the two ends c^1, c^2, of the winding have potentials of opposite sign and equal value. An insulating partition F, of known kind, separates the two sections of the high-tension windings. The ends of the high-tension coils are connected by slip rings, or segments of one slip ring, in the usual manner to the terminals of the secondary circuit. (*Accepted April 23, 1919.*)

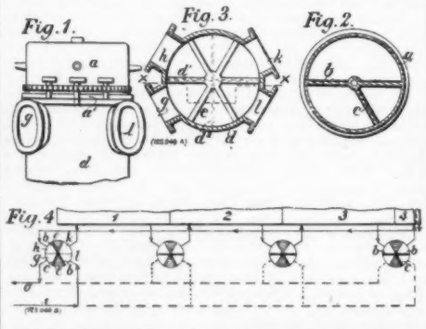
125,348. Johnson and Phillips, Limited, Charlton, and W. J. P. Orton, Charlton. Switch Gear. (3 *Figs.*) January 16, 1919.—The invention relates to the movable-truck type of switch gear for electric installation, and more particularly to means by which, when duplicate sets of bus-bars are provided, contact members carried by the movable truck can be readily adjusted to connect the current carrying parts of the truck to either set of bus-bars, when the truck is pushed home. A^1, A^2, are duplicate bus-bars on a fixed cubicle. B^1 and B^2 are porcelain insulators for the spring contact jaws C^1, C^2, of the switches of the bars A^1, A^2, of which the knife blade D is carried by an arm E

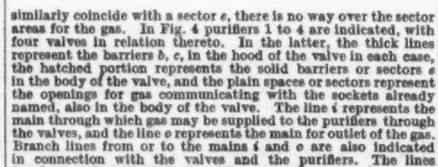


pivoted on a pin F secured to a travelling truck. The pin F is so placed that in one position of the arm E the knife blade D is opposite the contact C^1, and in another position of the arm is opposite the contact jaws C^2. The pin F is formed in the example illustrated as a bolt secured by a nut G. The arm E is secured in position so that the blade D is opposite to the fixed contact of the bus-bar in use by means of a screw-threaded bolt engaging in a hole provided in a fixed insulated bar L. In order to change over the contact switch from one bus-bar to the other, it is only necessary to withdraw the truck, release the arm E and rotate it about its central pivot and then secure it in position. (*Accepted April 23, 1919.*)

GAS ENGINES, PRODUCERS, HOLDERS, &c.

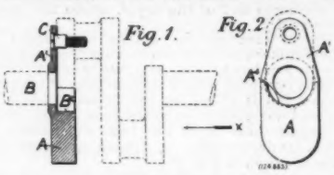
125,040. R. and J. Dempster, Limited, and W. F. Rodger, Manchester. Gas Purifiers. (10 *Figs.*) December 9, 1918.—The invention relates to a gas-diverting valve of the rotating type for use with purifiers and other gas apparatus, such as condensers. *a* is the hood portion of the valve, which is provided with a diametrical barrier, *b*, *b*, and a radial barrier *c*; these barriers extend down to the flange a^1. The area of sector formed by the barriers *b*, *c*, is approximately one-sixth of the area of the whole circle within the walls of the hood. *d* is the body part of the valve, which is divided into four parts by walls d^1, d^2, extending down the valve, but which at an upper part is provided with barriers dividing the circular area into six parts approximately equal, and of sector formation. That is to say, there is a pair of solid barriers or sectors *e* between each pair of pipe sockets or openings *g*, *h*, and *k*, *l*, and two cross-barriers formed by the walls d^1. When barrier *b*, *b*, of the hood coincides with barriers d^1, d^1, of the body *d*, gas cannot pass over the walls d^1, d^1. Also when *b* and *c* of the sector area in Fig. 2





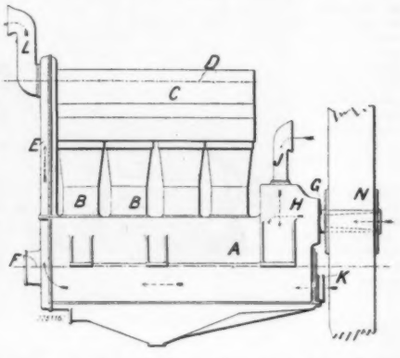
similarly coincide with a sector *e*, there is no way over the sector areas for the gas. In Fig. 4 purifiers 1 to 4 are indicated, with four valves in relation thereto. In the latter, the thick lines represent the barriers *b*, *c*, in the hood of the valve in each case, the hatched portion represents the solid barriers or sectors *e* in the body of the valve, and the plain spaces or sectors represent the openings for gas communicating with the sockets already named, also in the body of the valve. The line *i* represents the main through which gas may be supplied to the purifiers through the valves, and the line *o* represents the main for outlet of the gas. Branch lines from or to the mains *i* and *o* are also indicated in connection with the valves and the purifiers. The lines *i* and *o* are shown in full where the gas is assumed to be flowing in circuit, the remainder being shown in broken lines. The arrow heads also indicate the direction of flow throughout the system, and the branch lines are similarly to the lines *i* and *o* shown in full or otherwise according to whether gas is in circuit therethrough or not. (*Sealed.*)

124,883. W. Douglas, Kingswood, Bristol. Crank-shafts. (2 *Figs.*) April 3, 1918.—This invention relates to improvements in balancing engine crankshafts. According to this invention, a balance weight for an engine crankshaft is shaped to fit the edge of the crank-web where it abuts, and is provided with an extension adapted to be secured to the outer face of the crank-web, and pierced to receive the crankshaft. The balance weight A may be of any desired shape in accordance with the required amount and disposition of the weight, and is provided with an extension A^1 bored to closely fit the crank shaft B. One surface of the extension A^1 is machined to lie closely against the outer face of the crank-web B^1, and the edge A^4



of the balance weight is machined concentrically with the crank-shaft axis to lie closely against the correspondingly-shaped edge B^2 of the crank-web. The width of the extension A^1 may be tapered from the weight to the end which receives the screw C, so that the elevation of the face of the balance weight is pear-shaped, as shown in Fig. 2. (*Sealed.*)

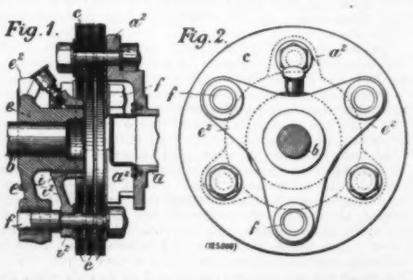
125,116. Sunbeam Motor Car Company, Limited, Wolverhampton, and L. Coatalen, Wolverhampton. Internal-Combustion Engines. (1 *Fig.*) May 26, 1916.—To improve the cooling of the interior of internal-combustion engines, particularly such as are used on aeroplanes, air is admitted at the end of the crank chamber opposite to that at which the camshaft drive is arranged, and the air passing along the crank chamber is then caused to travel up the camshaft gear casing, preferably after having passed through a centrifugal separator or filter. Thus the oil picked up by the air passing along the crank chamber is not carried up the camshaft gear casing. At the top of the casing there are provided outlets, preferably with a cowl or ventilator projecting in the opposite direction to the air draught. The crank chamber A contains a longitudinal crankshaft supported in bearings. The cylinders



are indicated at B and inside a casing C is a camshaft, the axis of which is indicated at D. This camshaft is driven by gearing located in the casing E and driven from the crankshaft, the axis of which is at F. The crankshaft also drives through a reducing gear on to the propeller shaft G, the reducing gear being located in the housing H. This housing is provided with an air funnel J causing air to pass in the direction of the arrows downwards into the crank-case. The propeller shaft G may be hollow and air may enter this in the direction of the arrows, and the crank chamber may be provided with one or more air inlets K. The air entering in this manner travels along the crank chamber, up the casing E, and out through the outlet funnel L. At the bottom of the casing E may be a filter or filters or a centrifugal separator may be used to separate the particles of oil from the air. Alternatively the filters or filtering devices may be located at the top of the casing. (*Accepted April 23, 1919.*)

MACHINE AND OTHER TOOLS, SHAFTING, &c.

125,009. Alldays and Onions, Limited, Birmingham, and A. W. Reeves, Birmingham. Shaft Couplings. (2 *Figs.*) September 18, 1918.—This invention relates to shaft couplings of the kind in which one of the shafts to which the coupling is applied is to be capable of a limited endwise or longitudinal movement without disconnecting the parts of the coupling, *a* is the clutch shaft which receives an endwise sliding motion, as is usual for putting the clutch (not shown) into and out of gear with the driving shaft, and *b* is the gear-box shaft which is to be rotated through the clutch shaft *a*, but which is incapable of



endwise or longitudinal movement. On the end of the clutch shaft *a* is a spider with three radiating arms a^2, a^2, a^2, and *c*, *c*, *c*, are flexible rings bolted to the arms a^2. Fixed on the end of the gear-box shaft *b* is the bush *e* of another spider having three radiating arms e^2, e^2, e^2, the ends of which have in them holes or bearings for the accommodation of the plain cylindrical heads of screw bolts *f*, *f*, *f*, the stems of which pass through the rings *c*, *c*, *c*, and also through the eyes or holes in the ends of arms i^2, i^2, i^2, radiating from the bush *i* of a spider fitted so as to be capable of sliding on the bush *e* of the spider on the gear-box shaft *b*. (*Accepted April 16, 1919.*)